MISSOURI INTEGRATED WATER QUALITY REPORT AND SECTION 303(d) LIST, 2022

Clean Water Act Sections 303(d), 305(b), and 314

Missouri Department of Natural Resources
Water Protection Program

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LIST OF ABBREVIATIONS

Abbreviation	Definition
AMP	Advanced Monitoring Projects
BMP	Best Management Practices
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
Chl*a*	Chlorophyll-a
CSI	Cooperative Stream Investigation
CSR	Code of State Regulations
CWA	Clean Water Act
CWC	Clean Water Commission
CWL	Clean Water Law
CWSRF	Clean Water State Revolving Fund
DHSS	Department of Health and Senior Services
EPA	Environmental Protection Agency
FFY	Federal Fiscal Year
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
IR	Integrated Report
LMD	Listing Methodology Document
LMVP	Lakes of Missouri Volunteer Program
LOWESS	Locally Weighted Scatterplot Smoothing
MCL	Maximum Contaminant Level
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
MGS	Missouri Geologic Survey
MOU	Memorandum of Understanding
MRBI	Mississippi River Basin Healthy Watersheds Initiative
MS4	Municipal Separate Storm Sewer Systems
MUDD	Missouri Use Designation Dataset
N	Nitrogen
NHD	National Hydrography Dataset
NLRS	Nutrient Loss Reduction Strategy
NNC	Numeric Nutrient Criteria
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service

Abbreviation	Definition
NRD	Natural Resource Damages
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PDWB	Public Drinking Water Branch
PFAS	Per- and Polyfluoroalkyl Substance
PPCP	Pharmaceutical and Personal Care Product
PS	Personal Service
QAPP	Quality Assurance Project Plan
RAM	Resource Assessment and Monitoring
RSMo	Missouri Revised Statute
SLAP	Statewide Lake Assessment Program
SSC	Site-Specific Criteria
SWCP	Soil and Water Conservation Program
TChl	Total Chlorophyll
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UAA	Use Attainability Analyses
UMC	University of Missouri - Columbia
UMRBA	Upper Mississippi River Basin Association
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VWQM	Volunteer Water Quality Monitoring
WBD	Watershed Boundary Dataset
WPP	Water Protection Program
WQA	Water Quality Assessment
WQS	Water Quality Standards
WRC	Water Resources Center
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The Missouri Integrated Water Quality Report was prepared by the Missouri Department of Natural Resources to meet requirements stated in Sections 303(d), 305(b), and 314 of the federal Clean Water Act (CWA). Section 303(d) requires states to submit a list of waters not meeting water quality standards (WQS). Section 305(b) requires an assessment of surface water quality and summary of monitoring and pollution control activities. Section 314 requires a status and trends assessment of publicly owned lakes. The primary purpose of this report is to provide the U.S. Environmental Protection Agency (EPA) and the residents of Missouri with an update on the condition of surface water quality in the state.

Data used in this report were generated through the Department's monitoring activities and the work of other agencies and organizations operating in conjunction with the Department or independently. Data were assessed using procedures contained in the Department's 2022 Listing Methodology Document (LMD). Monitoring and assessment mainly focused on classified, or designated-use, streams (115,700 miles) and lakes (321,736 acres) throughout Missouri.

The 2022 Section 303(d) list of impaired waters requiring Total Maximum Daily Loads (TMDLs) was approved by the Missouri Clean Water Commission (CWC) on April 12, 2023. This list includes 501 water body-pollutant pairs for both classified and unclassified waters. Seventy-seven water body-pollutant pairs listed in the 2020 Section 303(d) list were removed from the 2022 list. For the 2022 reporting cycle, data were available to assess approximately 12,013 miles of the 115,700 classified stream miles and 270,683 acres of the 321,736 acres of classified lakes in the state. Of the streams assessed, data indicated 4,310 miles, or 36 percent, fully supported their designated uses, while 4,854 miles, or 40 percent, were found to be impaired for at least one designated use. Notable causes of stream impairment included bacteria, low dissolved oxygen, mercury in fish tissue, heavy metals, and limited aquatic communities. Major known contaminant sources for streams included urban and rural nonpoint source pollution, municipal point sources, and mining activities. Of assessed classified lakes, 46,733 acres, or 17 percent, fully supported their designated uses, while 223,950 acres, or 83 percent, were impaired for one or more designated use. Notable causes of lake impairment included chlorophyll, nutrients, and mercury in fish tissue. Major known contaminant sources for lakes included nonpoint source pollution, municipal point sources, and atmospheric deposition.

Trophic status was summarized for a total of 236 lakes (270,902 acres) where 10 lakes (10,004 acres) were categorized as oligotrophic, 45 lakes (73,930 acres) as mesotrophic, 157 lakes (184,327 acres) as eutrophic, and 29 lakes (3,933 acres) as hypereutrophic.

Lake nutrient trends were conducted for a total of 64 lakes (198,229 acres) where 19 lakes (117,706 acres) had statistically significant nonparametric chlorophyll-a trend analyses, though none resulted in new 303(d) listings; 15 lakes (35,359 acres) had significant trends for Secchi transparency, 13 (3,230 acres) for total nitrogen, 13 (7,211 acres) for total phosphorus, and 8 (26,379 acres) for total suspended solids.

PART A: INTRODUCTION

A.1. Reporting Requirements

The *Missouri Integrated Water Quality Report for 2022* was prepared by the Department to fulfill reporting requirements contained in Sections 303(d), 305(b), and 314(a) of the federal CWA. CWA Section 303(d) requires each state to identify waters not meeting established WQS, and those which are also lacking an approved TMDL study or a permit requiring adequate pollution control. Water bodies on the 303(d) list are commonly known as "impaired waters." CWA Section 305(b) requires states to submit information pertaining to the overall status of its surface waters, and to provide a description of its water quality monitoring, management, and pollution abatement programs. It also provides an opportunity to include a description of the state's groundwater quality, as well as any related monitoring and protection programs. Under Section 314(a), each state is required to provide an assessment of the water quality of all publicly owned lakes, including a description of their status and trends.

The 2022 Missouri Integrated Report (IR) is based on EPA's *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act* supplemented by memorandums from the Office of Wetlands, Oceans, and Watersheds concerning IR and listing decisions. Under the CWA, the Department is required to report the quality of the state's waters to the EPA every two years. The EPA then compiles all state reports and prepares a summary for the United States Congress on the nation's waters. The report may later be used for rulemaking, budget appropriations, and program evaluations by federal legislators.

Missouri boasts a large network of water resources that contributes greatly to the quality of life in the state. This network of streams, lakes, and wetlands helps support state energy needs, sustains farming and industrial operations, provides habitat to wildlife, and offers a variety of recreational opportunities for residents as well the state's tourism industry. Therefore, the efficacy of the Department's regulatory and conservation work is imperative. In addition to fulfilling federal reporting requirements, information provided herein is intended to help guide future water resource management efforts in the state.

A.2. Changes from Previous Report

Processes for assessing and interpreting water quality data did not change much during the 2022 reporting cycle. The most notable change in WQS pertained to calculating hardness-dependent metals criteria, wherein median hardness replaced 25th-percentile hardness in the calculation. Any additional changes since the last reporting cycle only include updates to the state's LMD (Appendix A).

The 2022 LMD describes data that may be used for stream and lake assessments, as well as the assessment methods used to interpret WQS for 303(d) and 305(b) reporting. The Department is responsible for developing the LMD, which includes methods supported by sound science and advocated for by leading experts in the aquatic science fields. In accordance with the Code of State Regulations (CSR) at 10 CSR 20-7.050(4)(A), the 2022 LMD underwent a 60-day public comment period and was ultimately approved by the Missouri CWC on January 7, 2021. Due to

limitations of the COVID-19 pandemic, only one public availability meeting was held during the 2022 LMD public comment period.

The 2022 LMD was a revised version of the CWC approved 2020 LMD. Revisions were largely grammatical, with the Department striving for improved clarity and conciseness. Additional minor revisions were made as a result of public comment. These revisions included updating the citations and toxin thresholds associated with the Response Assessment Endpoints of the state's lake nutrient criteria; and clarifying language regarding fish tissue, as well as threatened waters. For additional information, please see Section *C.2.4.*

A.3. General Overview of the Assessment Approach

The Department's Water Protection Program (WPP) administers several water monitoring programs with the goal of generating sufficient data to assess all waters of the state. Monitoring is centered on three general approaches: (1) fixed station monitoring; (2) intensive surveys; and (3) screening level monitoring. WPP monitoring may also be used to support various Department initiatives and respond to problematic issues as they emerge. In addition, the Department partners with and coordinates monitoring among outside agencies, organizations, and universities to obtain the comprehensive set of information needed for assessing state waters. While this approach does not cover all waters of the state, its goal is to provide the greatest scope and quality of coverage possible given the resources available. Detailed information regarding the monitoring programs used to satisfy CWA reporting requirements can be found in Section *C.1*.

Designated uses were assessed whenever sufficient data of reliable quality were available, and previous assessments were updated whenever an adequate amount of new information became available. In some cases, errors discovered in previous assessments were corrected. For assessing use attainment, recent data (i.e., less than seven years old) were preferred. Due to resource limitations, however, data older than 10 years were used for assessments if the data were considered representative of present conditions.

In general, surface water assessments were largely based on data collected through October 31, 2020, concerning fish and macroinvertebrate communities, water quality, physical habitat, fish tissue contaminants, and water or sediment toxicity. Monitoring predominantly utilized a targeted sampling design that focused on selected waters, and which provided the majority of data used in the reported assessments. To a lesser extent, a probabilistic sampling design was used as a secondary approach for assessing state waters. These data were derived from fish community surveys conducted by the Missouri Department of Conservation's (MDC) Rapid Assessment Monitoring (RAM) Program. The Department, through EPA's Section 319 Nonpoint Source Grant Program, provided funding to the University of Missouri-Columbia (UMC) to support two lake monitoring programs, the Statewide Lakes Assessment Program (SLAP) and the Lakes of Missouri Volunteer Program (LMVP). These data were used to assess the aquatic life designated use, track lake trophic status throughout Missouri, and evaluate water quality trends for lakes with sufficient data.

While surface water assessments are the focus of this report, groundwater information is also included. The Department's Public Drinking Water Branch (PDWB) is the lead state entity responsible for monitoring groundwater quality in Missouri. Groundwater monitoring

information is provided along with a summary of groundwater contamination and an overview of the programs available to prevent and remediate such problems. For additional information about the PDWB beyond what is presented in this report, please see the Department's website at https://dnr.mo.gov/water/hows-water/water-we-drink.

A.4. Organization of Report

Beyond this introduction, the main body of the Missouri IR is organized into four general parts. Part B provides background information on Missouri's streams and lakes, describes the Department's water management approach and any programs that protect or improve surface water quality, gives an overview of costs and benefits of water management in the state, and provides a summary of important issues affecting water quality and associated management programs. Part C describes the Department's ongoing water monitoring programs, methodologies used to make assessment determinations for Section 303(d) listings, and major findings resulting from the assessment process. Part D focuses on the status of Missouri's groundwater resources as well as its related protection and monitoring efforts. Part E discusses Department procedures for public participation and stakeholder involvement in the development of the Section 303(d) list.

Appendices at the end of this report are reserved for listing water body-specific water quality, as well as other important supporting documents such as the LMD. The recently approved 2022 Missouri Section 303(d) list of impaired waters can be found in Appendix B.

PART B: BACKGROUND

B.1. Total Surface Waters

Missouri is home to slightly less than 6.2 million people with approximately one-half of the state's population residing in the metropolitan areas of Kansas City and St. Louis (US Census Bureau 2022). These cities were settled on the Missouri and Mississippi rivers – two of the nation's great rivers – which are essential to the economies of the regions. Beyond the two great rivers, Missouri's landscape contains a network of streams and lakes. These waters are expected to meet the needs of municipal, industrial, and agricultural operations and simultaneously serve as sources of safe drinking water, recreational sites, and wildlife habitats.

Missouri's classified streams total approximately 115,700 miles and classified lakes cover an estimated area of 321,736 acres (Table 1). Classified streams and lakes include those waters listed in Tables G and H of Missouri's WQS at 10 CSR 20-7.031. Classified waters are given priority under the Department's current water monitoring program. Unclassified streams contribute another 136,236 miles to Missouri's stream network, while unclassified lakes provide an additional 382,429 acres of surface area. Unclassified streams and lakes refer to waters not listed in Tables G and H of Missouri's WQS, which are still considered waters of the state. Unclassified waters are afforded protection under Missouri's WQS, albeit to a lesser extent than classified waters.

In order to be considered a classified wetland under Missouri's WQS 10 CSR 20-7.031(1)(E), wetlands must meet criteria established in the *United States Army Corps of Engineers (USACE) Wetlands Delineation Manual 1987*; however, a defined set of classified wetlands does not exist at this time. Previous work by the Missouri Geologic Survey (MGS), formerly known as the Department's Division of Geology and Land Survey, estimated wetland coverage in the state to be approximately 624,000 acres (Epperson 1992). In comparison, the United States Fish and Wildlife Service's (USFWS) National Inventory of Wetlands estimates approximately 1.4 million acres of wetlands currently exist in Missouri. This estimate is based on palustrine wetland types that include classified and unclassified streams and lakes, or portions of such. Regardless of the source, only estimates of wetland coverage exist for Missouri at this time. More precise measurements will not be available until a classified set of wetlands is formally adopted by the state. Work on remapping the National Wetlands Inventory for Missouri is anticipated to begin in 2023 and finish by 2030.

Table 1. Overview of Missouri surface waters.

Topic	Value	Scale	Source
State population (people)	6,177,957	--	US Census Bureau (2022 estimate)
State surface area (sq. miles)	68,746	--	US Census Bureau (2020 estimate)
Watershed subbasins (8-digit HUCs)	66	1:24,000	USGS NHD, USDA NRCS WBD
Designated-use streams (miles)*	115,700	1:24,000	WPP MUDD
Perennial (miles)	13,360	1:24,000	WPP MUDD
Intermittent (miles)	102,340	1:24,000	WPP MUDD
Losing streams (miles)	37,027	1:24,000	MGS
Great Rivers (miles)	1,053	1:24,000	WPP MUDD
Springs (number mapped)	4,487	1:100,000	MGS
General-use streams (miles)**	136,236	1:24,000	USGS NHD
Designated-use lakes (acres)*	321,736	1:24,000	WPP MUDD
General-use lakes (acres)**	382,429	1:24,000	USGS NHD
Freshwater wetlands (acres)	624,000	1:24,000	MGS

USGS NHD - US Geological Survey, National Hydrography Dataset
USDA NRCS WBD – US Dept. of Agriculture, National Resources Conservation Service, Watershed Boundary Dataset
WPP MUDD – Water Protection Program, Missouri Use Designation Dataset
MGS – Missouri Geological Survey
HUC – Hydrologic Unit Code

**Classified waters, which are waters with designated uses such as those listed in 10 CSR 20-7.031(1)(C).*
***Unclassified waters, which are those considered waters of the state possessing general-use protections as described in 10 CSR 20-7.031(3).*

B.2. Overview of Missouri’s Waters

Natural lakes in Missouri are limited to oxbow lakes, sinkhole ponds in karst areas, and open water systems in the wetlands of southeastern Missouri (Nigh and Schroeder 2002). Man-made lakes and ponds, known as reservoirs or impoundments, are common throughout the state. These systems range in size from large reservoirs created for hydroelectric generation and water supply to small ponds used for livestock watering and recreation. The two largest reservoirs in the state are Lake of the Ozarks (59,520 acres) and Harry S. Truman Reservoir (55,600 acres).

The state’s stream systems are diverse, and their physical characteristics reflect those of their watersheds. Missouri’s streams can be grouped into three aquatic subregions: the Central Plains, the Ozark Plateau, and the Mississippi Alluvial Basin (Figure 1; Sowa *et al.* 2005). Although the subregions are distinct with regard to terrain and geology, historical and present-day land cover, and stream morphology, streams within each aquatic subregion generally have similar structural features and functional processes which contribute to unique aquatic assemblages and ecological compositions.

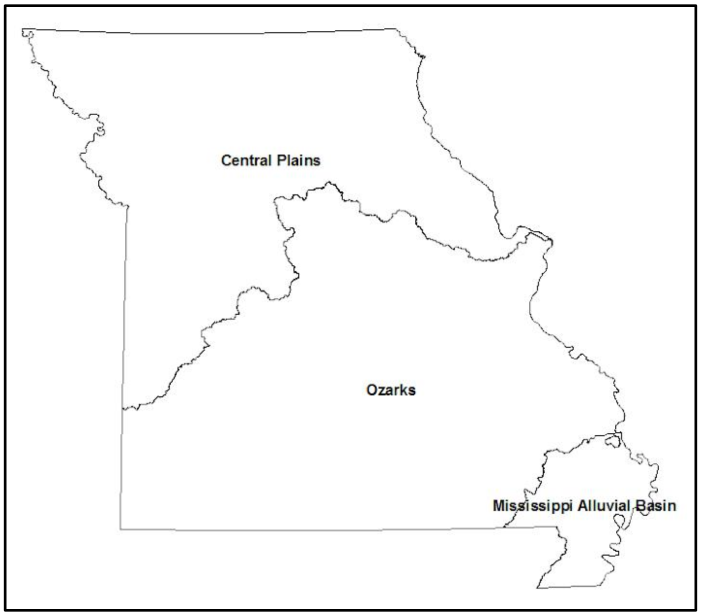

Figure 1. Missouri aquatic subregions

Central Plains of Northern and Western Missouri

The Central Plains covers the northern half of Missouri and extends southwest to also include the west-central region of the state. The western area formerly consisted of broad expanses of prairie, while the northern area contained smaller tracts of prairies separated by forests in valleys and on steeper slopes. The land is underlain by bedrock containing several relatively impermeable shale and clay layers. Today, this land is dominated by row crops on the flattest areas with the richest soils, pastures on irregular surfaces, and forests on some of the roughest tracts. Northern Missouri forests are more abundant today than they were historically (Nigh and Schroeder 2002).

Surface waters are generally turbid and affected by high rates of sediment deposition. Soil erosion induces sediment deposition, degrades aquatic habitat, and stresses aquatic life. Up to 8,000 miles of classified streams may be affected by these processes or by other types of aquatic habitat degradation, such as flow modification or channelization.

Rivers and reservoirs used as drinking water supplies are potentially vulnerable to contamination from herbicides due to storm water runoff and erosion. While there are no active drinking water reservoirs in Missouri impaired due to herbicides, such as atrazine, several reservoirs have shown localized, temporary impacts. The last single sample from a Missouri drinking water reservoir that exceeded maximum contaminant level (MCL) for atrazine was in Spring 2020. Local watershed management programs and source water protection plans have achieved success in reducing herbicide contamination. These types of planning and protection efforts, particularly if they include the use of agricultural best management practices to physically reduce storm water runoff and erosion from crops or pasture, are an effective tool to prevent, or minimize, herbicide impacts to drinking water reservoirs.

The quality of groundwater in northern and western Missouri is also influenced by the region's geology. Water supply sources include reservoirs and wells. Public and private wells obtain water from glacial drift deposits in northern Missouri and from underlying limestone bedrock in portions of northeastern, western, central, eastern, and southern Missouri. However, deep bedrock wells in many north-central and northwestern Missouri locations tap water supplies that are too mineralized for drinking water purposes. Some private wells in this part of Missouri exceed the drinking water standard for nitrate, and a very small number exceed the standard for pesticides especially in the Ozark Plateau (Brookshire 1997). This trend is most frequently caused by localized surface contamination of the wellhead and does not represent widespread contamination of the aquifer. Deeper aquifers are generally protected from surface contamination by impermeable strata. For county-based information on contaminant levels in private drinking water wells, please see the Missouri Department of Health and Senior Services (DHSS) online story map: https://storymaps.arcgis.com/stories/4a71c2f84c3349fcb7e4a528ac261b35.

The Ozarks

The hilly topography of the Ozark region contains areas with the greatest relief in the state. Pre-settlement vegetation was dominated by forests to the east, woodlands in the central and western Ozarks, and prairies along the outer boundary. Currently, the eastern Ozarks is dominated by forest, whereas the western Ozarks have considerably more land in crops and pasture, with woods concentrated on steeper terrain. The bedrock – consisting of limestone, dolomite, and sandstone – yields groundwater of excellent quality and of a volume generally adequate to supply urban, industrial, and other needs. The soil or subsoil has developed from weathering bedrock and is typically 20 to 80 feet thick. Some areas have extremely thin soils, but in locations where weathering has been extensive, soils may be 100 feet thick or more. The subsoil has moderate to high infiltration rates that contribute to the recharge of groundwater supplies. Streams are typically entrenched into bedrock and influenced to some degree by groundwater flow from large springs (Nigh and Schroeder 2002). Losing streams, which lose flow through underground infiltration, occur in karst areas throughout the Ozark region.

Ozark streams are generally clear, with base flows well sustained by many seeps and springs. Some streams and reservoirs in the Ozarks are becoming nutrient and algae enriched as a result of increasing human population and domestic animal production in their watersheds.

Groundwater contamination risks are moderate to high due to the permeability of the soil and bedrock. A variety of surface activities, including agricultural and suburban-urban stormwater and wastewater disposal, mining, stormwater runoff, lawn care, improper well construction or closure, and individual onsite wastewater disposal practices, pose threats to surface water and groundwater quality. However, overall water quality remains good as a result of efforts to protect vulnerable aquifers in the Ozarks.

Groundwater is a heavily relied upon source of drinking water in the Missouri Ozarks. The number of private drinking water wells statewide exceeds 180,000, but is likely higher due to an unknown number of wells installed prior to registration requirements. Most municipalities in the southern half of the state exclusively use groundwater as their drinking water supply; therefore, most private drinking water wells are located south of the Missouri River. One major groundwater concern is the potentially rapid and unfiltered transmission of contaminated surface

runoff or leachate (e.g., septic tanks, underground storage tanks, landfills, animal production or processing waste) through fractures or sinkholes directly into potable aquifers. Properly cased wells in deep aquifers rarely encounter water quality problems, but shallow or improperly cased wells are at risk.

Mississippi Alluvial Basin
The Mississippi Alluvial Basin consists of flat terrain that, at one time, was largely covered by seasonal or perennial wetlands called swamp forests. Very few of these swamp forests remain, as nearly all historic land cover in this region has been converted to crop production. Many streams have been channelized, and hundreds of man-made ditches now drain the landscape. The natural hydrographies of perennial and seasonal wetlands have been modified here more than anywhere else in Missouri, and aquatic habitat degradation is widespread.

Groundwater is abundant due to high infiltration rates on these flat fields. Public water supplies that tap deep aquifers provide good quality water, but shallow private wells may occasionally be impacted by nitrates and low level pesticides. The exceedance frequency of drinking water standards for nitrates and pesticides in private wells would be roughly similar to that of northern Missouri.

Great Rivers
The Great Rivers (i.e., the Missouri and Mississippi Rivers), albeit not classified as a subregion of its own, is made up of two unique aquatic ecosystems that represent significant water resources for Missouri. Approximately 1,053 miles of Great River habitat fall under Missouri's jurisdiction. The Great Rivers support a wide array of industrial and commercial needs, numerous recreational opportunities, and are utilized as primary drinking water sources for many communities. Fish fauna of the Great Rivers are comprised of a distinct assemblage of species, some of which occur nowhere else in Missouri (Pflieger 1997).

In northern Missouri, where surface and deep aquifer supplies are unreliable, many towns depend on the alluvial aquifers of nearby rivers. Landfills and industry in Kansas City and St. Louis have historically been located on river floodplains. Such activities have caused local contamination of the Missouri River aquifer in Kansas City and of both the Mississippi and Missouri River aquifers near St. Louis. While alluvial aquifers of the Great Rivers may yield large quantities of groundwater, pumping from them induces recharge from the rivers which introduces a potential source of contamination. Some municipal water supplies have been impacted by groundwater contamination in the past, therefore, groundwater from these aquifers requires treatment.

B.3. Water Pollution Control Program

Missouri Surface Water Quality Standards
Authority for enforcing Missouri Clean Water Law (CWL) and state regulations concerning water pollution resides with the Department's WPP. Missouri's approach to water quality management is primarily based on its WQS provided in 10 CSR 20-7.031. Under this rule, waters of the state are protected for specific designated uses. WQS are the basis for protecting designated uses, which in Missouri include: (1) drinking water supply; (2) human health

protection - fish consumption; (3) whole body contact recreation (e.g., swimming); (4) secondary contact recreation (e.g., fishing and wading); (5,6,7) aquatic life protection for warm water, cool water and cold water habitat; (8,9,10) aquatic life protection for ephemeral, limited, and modified aquatic habitats; (11) irrigation; (12) livestock and wildlife watering; and (13) industrial water supply. The Department is responsible for developing scientifically based WQS and proposing them to the Missouri CWC for adoption into state regulations. In accordance with the CWA, Missouri is required to review and update WQS at least once every three years.

To determine if designated uses are being protected, two general modes of WQS are used: narrative and numeric criteria. Narrative criteria are protective qualitative descriptions that may or may not be measured using numeric values. For example, 10 CSR 20-7.031(4)(D) states that "waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal, or aquatic life." In this case, quantitative methodologies utilize numeric values to determine if a narrative criterion is exceeded and if a substance is having a toxic effect on human, animal, or aquatic life. In other cases, narrative criteria alone may be used to assess attainment of designated uses. For example, under 10 CSR 20-7.031(4)(A), "waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly, or harmful bottom deposits that prevent full maintenance of designated uses." Streams with dense mats of floating sewage scum are in violation of this narrative standard. Numeric criteria, on the other hand, are explicit quantitative water quality limits used to determine if designated uses are attained or not. Quantitative methods always use measured numeric values to examine if the numeric criterion is being upheld.

Additional protection to state waters is provided in the antidegradation component of WQS contained in 10 CSR 20-7.031(3). Missouri's antidegradation policy consists of three tiers. In the first tier, a level of water quality necessary to protect public health and existing in-stream uses shall be protected and maintained. In the second tier, in cases where water quality is better than applicable water quality criteria, the existing quality shall be protected and maintained. Lowering in-stream water quality is only allowed in such cases when it is determined necessary for important economic and social development. This second tier also contains a set of strict provisions that must be followed for any permitted degradation of state waters. In the third tier, there shall be no degradation of water quality in outstanding national or outstanding state resource waters as listed in Tables D and E of 10 CSR 20-7.031.

Point Source Pollution Control

The Department, under the State of Missouri's authorization, administers a program equivalent to the National Pollution Discharge Elimination System (NPDES). Under Missouri CWL, the Department issues permits for discrete wastewater discharges (e.g., human wastewater, industrial wastewater, stormwater, confined animal operations) that flow directly into surface waters. Industrial, municipal, and other facilities are regulated in order to ensure that surface waters receiving effluent meet WQS. Permits include requirements for limitations on specific pollutants (e.g., biochemical oxygen demand, ammonia as nitrogen, chloride), monitoring and reporting, and the implementation of best management practices (BMPs) as needed. The Department requires wastewater facilities to meet certain design specifications, while plant supervisors and other operators are required to be certified at a level that corresponds to the plant's size and complexity. Approximately 1,176 miles of waters assigned specific designated uses are on the 2022 303(d) list

as a result of discharges from wastewater treatment facilities (WWTFs) or wastewater treatment plants (WWTPs). For more information on regulated discharges and available permits, please visit: http://www.dnr.mo.gov/env/wpp/permits/index.html.

Concentrated animal feeding operations (CAFOs) in Missouri are required to be designed, constructed, operated, and maintained as "no discharge" facilities. Manure and wastewater produced by CAFOs are land-applied rather than discharged to streams. Permit requirements include development and implementation of a nutrient management plan which contains a strategy for onsite BMP utilization. There are approximately 500 permitted CAFOs in Missouri, the majority of which are for swine and poultry production. For more information on CAFOs, please visit: https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/concentrated-animal-feeding-operation-cafo.

The Department issues land disturbance permits to control stormwater runoff from disturbed sites comprising an area of one acre or more and/or from sites disturbing less than one acre if the construction activity is part of a larger common plan of development or sale that would disturb one acre or more. Land disturbance permits require usage of BMPs to prevent sediment and other pollutants from migrating into surface waters. A stormwater pollution prevention plan must also be prepared prior to issuance of any permit. Some activities that commonly require land disturbance permits include housing and building construction, road and dam construction, and utility projects. For more information on land disturbance permits, please visit: https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/stormwater/construction-land-disturbance.

Discharge of stormwater runoff transported through Municipal Separate Storm Sewer Systems (MS4s) is another regulated activity. Separate storm sewer systems include any method of conveying stormwater including streets, ditches, swales, or any man-made structure that directs flow. There are 165 identified MS4s in Missouri. Each one is required to develop and implement a stormwater management program to prevent and reduce any contamination of stormwater runoff and prevent illegal discharges. The stormwater management program includes six minimum control measures: (1) public education and outreach; (2) a process for public involvement and participation; (3) illicit discharge detection and elimination; (4) construction site stormwater runoff control; (5) post-construction stormwater management; and, (6) pollution prevention/good housekeeping for municipal operations. For more information regarding municipal stormwater regulations, please visit: https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/stormwater/municipal-separate-storm-sewer-systems-ms4.

The Department also issues permits for discharging regulated stormwater from eleven industrial categories, covering 30 sectors of activity. These permits require usage of BMPs to prevent industrial pollutants from being released into surface waters. A stormwater pollution prevention plan must also be prepared prior to issuance of any permit. If a facility has all industrial activities not exposed to stormwater, they may request a no exposure certification instead of a permit. Some activities that commonly require industrial stormwater permits include motor freight transportation, metal fabricating, and wood processing. For more information regarding municipal stormwater regulations, please visit: https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/stormwater.

Nonpoint Source Pollution Control

Nonpoint source (NPS) pollution comes from many diffuse sources and is defined as the transport of natural and man-made pollutants by rainfall or snowmelt, moving over and through the land surface and entering lakes, rivers, streams, wetlands or groundwater. Some common sources of NPS pollution include row crops and agricultural fields, impervious surfaces such as road surfaces and parking lots, as well as septic systems and underground storage tanks. In Missouri, significant contributors of NPS pollution include agricultural lands, urban areas, and abandoned mines. The Department takes two general approaches in managing NPS pollution: one that is volunteer-based and offers monetary incentives and grants, and another that is regulation-focused.

Many NPS pollution sources may be addressed by the Department's NPS Management Program. This program engages concerned citizen organizations, landowners, federal, state and local governments, as well as universities and other stakeholders to implement NPS control practices and monitor improvements to water quality and habitat. One priority of the Department's 2020-2025 draft NPS Management Plan is to restore impaired waters and to protect unimpaired high-quality waters. Grant funds provide local citizens the knowledge and ability to improve their land use practices and to protect and improve water quality. The NPS Management Program's mission is to "protect and improve the quality of the state's water resources using locally led approaches to address nonpoint source impairments." NPS projects target numerous types of runoff pollutants (e.g., sediment, fertilizers, pesticides, bacteria, animal waste) through the implementation of land management measures (e.g., stream bank stabilization, riparian and wetland improvements) and cost-share programs. With the exception of special projects, funded activities are carried out as part of a larger watershed plan to improve specific stream and lake resources. Project funding is provided by the EPA though Section 319(h) of the federal CWA and supports 60 percent of total project costs. The NPS Program is a key partner of the Natural Resources Conservation Service's (NRCS) Mississippi River Basin Healthy Watersheds Initiative (MRBI) and the recent NRCS-EPA collaborative National Water Quality Initiative. For more information, please visit the Department's NPS Management Program webpage: https://dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319.

The Department's Soil and Water Conservation Program (SWCP) provides financial incentives for landowners to implement conservation practices that reduce soil erosion and protect water resources on their lands and in the watersheds surrounding their lands. To achieve this, the SWCP administers a cost-share program through each of the 114 soil and water conservation district offices in Missouri. Each office assists landowners by providing both technical and financial assistance of up to 75 percent of the estimated cost for certified conservation practices. In addition, SWCP is a contributing partner of the Regional Conservation Partnership Program, which leverages a partnership agreement to provide funding to assist agriculture producers in achieving conservation goals. SWCP's primary funding source comes from a one-tenth-of-one-percent parks, soils, and water sales tax that is shared with the Division of State Parks. Please visit the SWCP webpage for more information: https://dnr.mo.gov/land-geology/soil-water-conservation.

While general NPS pollution is not formally regulated, there are instances in which some types of NPS may fall under a form of water pollution control. As noted earlier, permits are issued to

control stormwater runoff from land disturbance activities of an acre or more, as well as for certain industries like biodiesel manufacturers and agrichemical producers. Some additional activities permitted by the state include clay, rock, and mineral mining; abandoned mine land reclamation; land application of human and animal wastewater; and underground petroleum storage. Construction, placement, dredging and filling, or general earth moving activities within a wetland or water body requires a 401 certification from the Department and 404 permit from the USACE.[1] Single family residential wastewater systems, or septic systems, which are known NPS pollution sources fall under the jurisdiction and responsibility of the Missouri DHSS.

TMDL Program

TMDLs are tools to restore water quality and inform watershed planning. A TMDL calculates the maximum amount of a pollutant that a water body can receive and still meet and maintain WQS. TMDLs allocate calculated pollutant loads to the various sources in a watershed and these allocations become the goals for pollution reductions. All TMDLs incorporate a margin of safety to account for any uncertainties in scientific and technical understanding of water quality in natural systems. The margin of safety also provides assurance that WQS will be met after the allocations to point and nonpoint sources have been achieved.

To accompany each TMDL, the Department also develops supplemental implementation strategies documents to provide guidance to landowners and other stakeholders in the watershed on approaches that would help meet the goals established in the TMDL. These strategies documents are for informational purposes only and do not impose any new requirements or costs on landowners or businesses operating in the watershed.

To date, the Department has addressed 251 water quality impairments through TMDLs, impacting a total of 165 streams and eight lakes. The Department makes all draft TMDLs and implementation strategies documents available for public review and comment through a 45-day public notice period. All approved and draft TMDLs, as well as any existing implementation strategies, are available on the Department's TMDL webpage: https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

Federal regulations at 40 CFR §130.7 require TMDLs to be established for all waters on the 303(d) list of impaired waters. In accordance with this regulation, individual water body impairments on the 303(d) list are prioritized for TMDL development. Impairments identified as high priority are specifically targeted for TMDL development prior to the issuance of the next subsequent 303(d) list. The Department reevaluates all priority rankings and development schedules with each new 303(d) list. The Department's framework for making prioritization decisions for TMDL development is available on the TMDL webpage linked above. Questions or requests for information regarding TMDLs can be submitted by email to tmdl@dnr.mo.gov.

B.4. Cost-Benefit Assessment

Section 305(b) requires the state to report an estimate of the economic and social cost-benefits of realizing the objectives of the CWA. Unfortunately, exact cost information pertaining to the

[1] https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/section-401-water-quality

improvement and protection of water quality is often difficult to calculate. The Department tracks its own programmatic costs, however, those representing municipal, private, and industrial treatment facility operations, and, in some cases, the implementation of BMPs, are not typically readily available. Economic benefits, in monetary terms, resulting from water protection efforts are even more difficult to calculate. The following paragraphs provide an overview of Department spending related to various aspects of water pollution control and prevention.

The Department spends an average of $1.3 million on the United States Geological Survey (USGS) ambient water quality monitoring network each year—the USGS contributes approximately $200,000. Annual costs for permit issuance averaged approximately $3.2 million for fiscal years 2019 and 2020—this only includes personal service (PS), fringe, and indirect on PS and fringe, as expense and equipment is not coded to the activity level. On average, approximately $9.6 million is spent each year for other facets of water pollution control and administrative support.

Another significant expense includes grants aimed at improving water quality. The Department awards funding provided by the EPA under Section 319 of the CWA for projects that address NPS pollution. In federal fiscal years (FFYs) 2018 to 2022, approximately $3.6 to $3.9 million was available annually for NPS projects. Approximately $200,000 and $400,000 is awarded annually for planning and implementing projects, respectively.

Between FFYs 2020 and 2022, the Department's SWCP has distributed an average of $33.7 million directly to landowners to address agricultural NPS pollution and to conserve and protect the quality of water resources in agricultural landscapes. Over FFYs 2020 to 2022, a total of $101.1 million was spent on SWCP conservation practices aimed at reducing soil runoff from farmland. Conservation practices have focused on managing animal waste, livestock grazing, irrigation, nutrients and pests, protecting sensitive areas and reducing erosion. Over the life of these conservation practices (i.e., generally 10 years), it is estimated that 3.7 million tons of soil will be protected.

Missouri's Clean Water State Revolving Fund (CWSRF) loan program provides low-interest financing to construct wastewater and stormwater projects that improve water quality. Other eligible projects might include, but are not limited to, those related to NPS or water conservation and reuse. During the 2022 reporting period, the Department entered into four direct loans and thirty-eight grants for a total of $12,606,211 in CWSRF binding commitments. Funding for the CWSRF is provided by the EPA with matching funds from the State of Missouri. As of September 30, 2022, the CWSRF's cumulative binding commitments have totaled $3,368,421,621, resulting in estimated interest savings for Missouri communities of $1,088,520,978 as compared to conventional loans.

The Department's PDWB administers a statewide Source Water Protection Program designed to assist local communities in protecting the quality of their raw drinking water sources. While participation with the State program is voluntary on the part of public water systems, the Department provides technical assistance and guidance to interested systems, reviews submitted local voluntary protection plans, and provides recognition of local communities actively working to protect their raw water sources. Financial assistance for source water protection activities is

budget-dependent, but the Department has offered abandoned well plugging grants to eligible public water systems since 2008. Financial assistance for source water protection plan development or implementation has not been available in recent years, but the PDWB is currently developing a program to address this need. Contact the Department's PDWB for more information regarding the availability and details of these assistance programs.

The Department, under Missouri Revised Statute (RSMo) §644.096 of the Missouri CWL and the Missouri Natural Resource Damages (NRD) Trustee Council, based primarily upon authority vested in the federal Comprehensive Environmental Response, Compensation, and Liability Act (also known as Superfund), is responsible for assessing injuries to and restoring natural resources that have been impacted by environmental hazards. The Department's NRD staff, together with federal NRD trustees such as the United States Fish and Wildlife Service and United States Forest Service (USFS), have reached settlements totaling approximately $70 million to restore impacted natural resources and the services they provide. NRD assessment and restoration settlements were largely the result of impacts from heavy metal mining in southeast and southwest Missouri. Two regional restoration plans, which guide restoration planning activities, have been developed to date, including one for the Southeast Missouri Ozarks Lead Mining District and another for the Missouri portion of the Tri-State Mining District located on the Springfield Plateau. The trustees are actively funding restoration projects in these regions to ameliorate the negative impacts of heavy metals on natural resources.

Missouri is strongly committed to protecting water quality in its 115,000+ miles of streams and 321,000+ acres of lakes and reservoirs. As highly valued public resources, good water quality in these waters promotes a healthy economy in Missouri, which in turn provides support for better water quality. Sixty-one percent of Missouri residents participate in water-based recreational activities, much of which is fishing, swimming, and boating on the state's lakes and reservoirs. Visitors to Missouri for water-based recreation are increasing by about 2.7 percent per year, while total visitor expenditures are increasing by 5.4 percent per year. Water-based recreational activities generate $14.9 billion in consumer spending and directly support 33,000 jobs. Purchases related to water-based activities generate more than $880 million in state and local taxes.

B.5. Special State Concerns and Recommendations

Missouri has accomplished significant advances in environmental quality due to its water protection programs. Municipal and industrial wastewater discharged to state waters is not permitted without considering potential impacts to receiving waters. Improved forestry and agriculture practices have reduced polluted runoff and sediment loss. The same conservation practices have helped preserve farmland and enhance wildlife habitat. Although Missouri waters are cleaner today than they were 40 or 50 years ago, substantial, persistent threats to environmental quality remain. Major contemporary environmental concerns may be divided into categories as described in the following paragraphs.

Agricultural and Urban Nonpoint Sources

Managing agricultural and urban runoff is an ongoing challenge in Missouri. Both sources have substantial influence on water quality. Cropland runoff may contain large amounts of sediment, nutrients, and pesticides. Pollutant loads from urban runoff include sediment from new

development and construction; oil, grease, and other chemicals from automobiles; nutrients and pesticides from commercial and residential lawn management; grass clippings and other organic materials from brush disposal; road salts; and heavy metals. Impervious surfaces, such as roadways and rooftops, increase water volumes in streams during storm events and lower base flows during dry periods. This hydrological pattern frequently results in eroded stream banks, widened channels, and degraded habitat. Moreover, impervious surfaces are easily heated by the sun which warms surface runoff and ultimately causes stream temperatures to increase. Changes in water quality and habitat condition that generally accompany agricultural and urban runoff impair aquatic life and diminish the value of other designated uses.

Department programs that are both regulatory and voluntary have proven effective for managing runoff; however, such programs are not available to address all runoff problems occurring across the state. Additional monitoring, resources, and external support are needed to eliminate the threat of NPS runoff.

Municipal and Industrial Sources

WWTFs and other point source dischargers have a significant impact on water quality. Point sources are subject to NPDES permit requirements; however, pollution incidents still happen occasionally. Failing treatment systems, bypasses, accidental spills, or illicit waste disposal are some types of violations that can occur. Discharges of inorganic nutrients may promote excessive algal growth in receiving waters. Raw or partially treated sludge releases degrade aquatic communities as organic matter decomposes and dissolved oxygen is depleted in the water. Other toxic substances can have more direct effects on aquatic life.

Pharmaceutical and Personal Care Products (PPCPs) include any product used by individuals for personal health or cosmetic reasons, or those used by agribusiness to enhance the growth or health of livestock. Some examples of PPCPs include endocrine disrupting sex hormones, antibiotics, steroids, antidepressants, and various prescription and over-the-counter drugs. Treatment facilities are not equipped to eliminate PPCPs from wastewater; therefore, these substances are passed on to receiving streams and lakes. While little is known about the impacts of PPCPs on human health, aquatic organisms at any developmental stage may be affected. For example, male fish have been documented to experience feminization (disruption of normal gonad development and function) as a result of estrogens being released into the water.

Per- and polyfluoroalkyl substances (PFAS) are contaminants of emerging concern. The fluorinated carbon chains, which give these chemicals their name, also give PFAS the attractive properties (e.g., grease and water repellence, stick and stain resistance) that have led to their rapid and widespread use across industries and households. Extensively used in surface coatings and protectants, PFAS can be found in a multitude of settings, such as in facilities utilizing aqueous film-forming foams for fire suppression, as well as in oil refineries, metal finishing plants, and textile mills; and in a myriad of products, including, but not limited to, pulp and paperboard (e.g., food packaging); cookware; textiles and clothing with synthetic fibers; organic chemicals; plastics; resins; as well as metal products. Known as "forever chemicals," PFAS include thousands of stable and environmentally persistent compounds that can easily traverse environmental matrices. As such, waste-disposal facilities (i.e., WWTFs and landfills) can even act to concentrate PFAS in the environment. Concerning to both environmental and human

health, PFAS biomagnifies through the food chain, elevating concentrations within fish that may be consumed by humans and other organisms. Further, these chemicals are related to decreased immune responses; disruptions to lipid, liver, thyroid function; adverse effects on the reproductive system; hormone imbalances; behavioral disorders; and increased cancer risk. In aquatic biota, PFAS are linked to morphological and behavioral developmental anomalies. For more information on PFAS and other emerging contaminants, please visit: https://dnr.mo.gov/water/hows-water/pollutants-sources/pollutants-emerging-concern.

The Department has worked with numerous entities to upgrade municipal and industrial WWTFs in order to meet WQS. While most treatment facilities are in compliance with current WQS, additional and continued facility upgrades are anticipated in an effort to further alleviate water quality degradation.

Abandoned Mines

Current and past mining operations have caused significant changes to water quality. Heavy metals, such as lead and zinc, may enter streams from smelters, mills, mine water, and tailings ponds. However, abandoned lead-zinc mines and their tailings continue to impact waters for decades after mining activity has ceased. Mines left exposed to the elements may pollute waters via stormwater, erosion, and fugitive dust. Through these same pathways, mines that were properly shutdown after operations, but then reclaimed for another land use, have also polluted the environment.

Missouri's Superfund Program is addressing some of these concerns. Despite such efforts, long-term impacts are expected to remain until additional resources are made available. Monitoring will need to target abandoned mines that are suspected of contributing heavy metals to streams. Similarly, reclaimed mines may need to be inspected periodically to ensure post-closure actions have been maintained. New mineral extraction operations are managed under state permits. Areas of the state more sensitive to disruption (i.e., those of a more pristine condition) are carefully and rigorously reviewed under antidegradation processes when being considered for mining potential.

Concentrated Animal Feeding Operations

As of 2022, there were about 500 actively permitted Class I CAFOs in Missouri. These include operations containing at least 1,000 beef cattle, 700 dairy cows, 2,500 swine weighing over 55 pounds, or 125,000 broiler chickens. Class II and smaller animal feeding operations are not permitted. Facilities that generate large amounts of animal waste and manure have the potential to cause serious water pollution problems. Land application of manure on agricultural fields is the preferred method of manure management.

Missouri's CAFO laws and regulations are designed to minimize any threats to water pollution and ensure long-term protection for the environment. Multiple permits may be required for the construction and operation of a CAFO, including a construction permit for earthen basins, a land disturbance permit, and an operating permit. Additionally, operating permits require a nutrient management plan to be developed and the implementation of certain BMPs for the land application of animal manure.

Mercury in Fish Tissue

Safe consumption of fish from Missouri waters continues to be threatened by elevated mercury levels. For the 2022 assessment cycle, 840 stream miles and 27,327 lake acres were listed as impaired for mercury in fish tissue. Waters that have been monitored for long periods have shown that mercury levels in fish tissue have remained relatively stable over time. Without adequate air pollution control, future monitoring will likely detect additional water bodies with elevated levels of mercury in fish tissue. All fish contain some, usually small, amounts of chemical contaminants. In most instances and for most people, the health benefits of eating fish outweigh the potential risks from contaminants. There are occasions, however, when limited or no consumption of certain fish is appropriate.

DHSS issues an annual health advisory and guide for safely consuming fish. Due to mercury contamination, DHSS has issued a statewide consumption advisory for sensitive populations, which include children younger than 13, pregnant women, women of childbearing age, and nursing mothers. These populations have been advised to limit consumption of walleye, largemouth bass, spotted bass, and smallmouth bass longer than 12 inches in length to one meal per month; flathead, channel, and blue catfish longer than 30 inches in length to one meal per month; and all other sport fish to one meal per week. Additional advisories for all consumers due to other contaminants may be found at http://health.mo.gov/living/environment/fishadvisory/.

To reiterate, in most instances and for most people, the health benefits of consuming fish outweigh the potential risks from contaminants. The Department plans to continue monitoring for mercury levels in fish for the foreseeable future.

Eutrophication

Nutrient pollution, also known as eutrophication, is an ongoing water quality concern for Missouri state waters. The macronutrients, phosphorus (P) and nitrogen (N), while essential to aquatic life in limited quantities, are particularly problematic when present in excess. Excessive P and N amplify the growth of algae, resulting in unsightly and potentially harmful algal blooms that further degrade water quality by driving down dissolved oxygen concentrations in the water. Although eutrophication is a statewide concern, NPS runoff and heavy residential development, particularly around portions of the state's recreationally important large reservoirs, can threaten water quality in coves and shoreline areas. The sheer size of Missouri's large recreational reservoirs and their often rugged local topography make the construction of centralized wastewater collection and treatment systems difficult. Proper maintenance of lakeside septic systems is, therefore, critical, as the nutrient-enriched water from failing systems can—and likely will—eventually enter the nearby lake.

As of 2018, Missouri's WQS include ecoregional-based, statewide numeric lake nutrient criteria (NNC), as well as site-specific lake numeric nutrient criteria (SSC). These nutrient criteria have been implemented to ensure the deleterious impacts of eutrophication are mitigated without adverse impacts to the health and vitality of the aquatic life living in Missouri's lakes. Missouri's NNC apply to all lakes that are waters of the state, except the natural oxbow lakes in the Big River Floodplain ecoregion, and have an area of at least 10 acres during normal pool conditions. Additional SSC may be developed to account for the unique characteristics of individual water bodies that affect trophic status, such as lake morphology, hydraulic residence time, temperature,

internal nutrient cycling, or watershed contribution from multiple ecoregions. A current list of lakes with SSC can be found in Table N of 10 CSR 20-7.031.

The imposition of limits on most centralized wastewater discharges to lakes, such as those discharges to Table Rock Lake, have markedly reduced nutrient levels in many problematic, nutrient-rich lakes. The Department continues to track lake nutrient conditions across the state and offers various programs and grants to help address any issues and concerns. For example, in the past, the Department awarded $1,000,000 to the Upper White River Basin Foundation for the purpose of assisting homeowners with the cost of replacing failing septic systems through a combination of grants and loans through the WPP's Financial Assistance Center. Additionally, since 1997, the Department has financially supported the UMC lake monitoring programs (i.e., SLAP and LMVP) through CWA Section 319 NPS subgrants. With the goal of understanding the impacts of NPS eutrophication on Missouri's lakes, these programs focus on determining current lake water quality, monitoring for long-term changes in lake water quality, identifying potential nutrient-related water quality issues, and educating the public on such issues.

Missouri WQS do not include statewide nutrient criteria for streams at this time; however, Missouri presently utilizes dissolved oxygen as an endpoint response variable to assess and address eutrophication impacts in streams.

As part of a commitment to reducing surface water eutrophication within its borders and beyond to the Gulf of Mexico, Missouri is one of 12 states within the Mississippi River/Atchafalaya River Basin to develop a specific, strategic mitigation plan for addressing the factors contributing to the Gulf Hypoxic Zone. Missouri's Nutrient Loss Reduction Strategy (NLRS), which was released in 2014 following three years of collaboration, reflects the combined efforts of the Department, state and federal partners, and private citizens. Through the NLRS's proposed recommendations, the Department aims to improve local water quality while reducing statewide nutrient contributions to the Mississippi River and, ultimately, the Gulf of Mexico. Targeting reductions in point and NPS nutrient pollution, this adaptive strategy combines proven actions and practices of the past with newer ideas drawn from the scientific literature and actions taken by local partners, as well as from experiences in neighboring states. Thus far, NLRS progress includes implementing NNC for lakes, implementing a statewide soil moisture network, and encouraging cooperator participation in 4R Nutrient Stewardship. In the coming years, the Department plans to develop model-based historical nutrient baselines for both total nitrogen and total phosphorus, and finalize Missouri's Nutrient Trading Program as well as the Total Phosphorus Reduction Target Rule. For more information on the NLRS and proposed actions, or to review the 2022 NLRS progress update, please visit the Department's website at https://dnr.mo.gov/water/what-were-doing/water-planning/nutrient-loss-reduction-strategy.

Groundwater Protection

Missouri continues to increase its protective services of groundwater. The Department has programs to register and inspect underground storage tanks and oversee the cleanup of leaking underground storage tank sites (https://dnr.mo.gov/waste-recycling/investigations-cleanups). Additional programs address wellhead protection, the plugging of abandoned wells, sinkhole mitigation (https://dnr.mo.gov/land-geology/hazards), and the closing of hazardous waste sites (https://dnr.mo.gov/waste-recycling/investigations-cleanups). The WPP also includes a

groundwater monitoring network accompanied by educational programs for those involved in the application of farm chemicals and transport of hazardous materials. These educational programs are available to the general public. Additional information may be found at https://dnr.mo.gov/water/hows-water/state-water/groundwater.

Additional Concerns

Beyond the threats and concerns mentioned above, others remain. Fish and macroinvertebrate data from across the state indicate biological communities are impacted by degraded aquatic habitat. Physical alterations of the channel, alterations in stream flow patterns, removal of much or all of the riparian zone, and upstream land-use changes in the watershed are all significant contributors to this problem. Stream channelization is prevalent in the northern and western Central Plains as well as the Mississippi Alluvial Basin in the southeastern corner of the state. Large-scale channelization projects no longer occur, but smaller projects are still carried out to facilitate urban and residential development. Stream road crossings are an additional source of habitat degradation. Low-water crossings and improperly placed and/or sized culverts, which are frequently encountered across Missouri, create upstream barriers to fish passage and are primary points of habitat fragmentation.

Aquatic nuisance species pose a significant threat to the aquatic resources and economy of Missouri. Several invasive species are already present in some Missouri waters, including animals such as the zebra mussel (*Dreissena polymorpha*), silver carp (*Hypothalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), black carp (*Mylopharyngodon piceus*) and grass carp (*Ctenopharyngodon idella*); and plants such as Eurasian watermilfoil (*Myriophyllum spicatum*), waterthyme (*Hydrilla verticillata*), and brittle naiad (*Najas minor*). Northern snakehead fish (*Channa argus*) has been found downstream in Arkansas and caught once in Missouri. Algae commonly known as “rock snot” (*Didymosphenia geminata*) has been found in neighboring states—the closest confirmed observation has been on the White River south of the Missouri-Arkansas border. This algae, like many other invasive species, is a continual threat due to human dispersal especially via felt-soled wading shoes and other recreational equipment. MDC has been implementing its Aquatic Nuisance Species Management Plan since 2007.

Long term climatic variability presents additional challenges to the state’s aquatic resources. While precipitation is projected to increase in the Midwest in winter and spring, with intense events occurring more frequently throughout the year, warmer summer temperatures may increase the likelihood of drought. Resulting changes in stream flow would be more likely to have a negative impact on aquatic habitats and residing organisms. In the Midwest, cold water fish species are projected to be replaced by cool water species. Aquatic invasive species are also projected to benefit under a changing climate as they tend to thrive under a wider range of environmental conditions compared to those typically tolerated by native species (Karl *et al.* 2009). According to Missouri’s Forest Resource Assessment and Strategy, riparian forests could become increasingly vital for the protection of stream banks by providing filtering and shading functions under a significantly wetter and warmer climate (Raeker *et al.* 2010).

PART C: SURFACE WATER MONITORING AND ASSESSMENT

C.1. Monitoring Program

The goal of the Missouri water quality monitoring program is to provide sufficient data for conducting a water quality assessment of all waters of the state. This is achieved by meeting six specific objectives: (1) characterizing background or reference water quality conditions; (2) better understanding daily flow events, seasonal water quality variations, and their underlying processes; (3) characterizing aquatic biological communities and habitats, and distinguishing differences between the impacts of water chemistry and habitat quality; (4) assessing time trends in water quality; (5) characterizing local and regional impacts of point and NPS pollution on water quality, which includes compliance monitoring and development of water quality based permits and TMDL studies; and, (6) supporting development of strategies to return impaired waters to compliance with WQS.

The Department implements four strategic monitoring approaches to meet the objectives above: (1) fixed station monitoring; (2) intensive and special surveys; (3) screening level monitoring; and (4) probability-based sampling. Missouri's Water Quality Monitoring Strategy (MDNR 2022) provides an in-depth discussion of the entire water quality monitoring program and strategy. All Department monitoring is conducted under approved Quality Assurance Project Plans (QAPPs) with the Department's Environmental Services Program (ESP) laboratory. The Department's Quality Assurance Management Program was previously approved by EPA.

To maximize efficiency, the Department routinely coordinates its monitoring activities with other agencies to avoid overlap and to provide and receive interagency input on monitoring study design. Examples of this include:

- Collaboration with MDC on fish tissue monitoring, macroinvertebrate collection, and reference stream identification.
- A memorandum of understanding (MOU) with the Upper Mississippi River Basin Association (UMRBA) for conducting studies on the Mississippi River.

Fixed Station Monitoring

The fixed station monitoring network is designed to obtain water chemistry, sediment, fish tissue, and biological monitoring sites equitably among major physiographic and land use divisions in the state. Selected sites must meet one of the following two criteria: (1) the site is believed to have water quality that represents many similarly sized streams in the region due to likeness in watershed geology, hydrology, and land use, as well as an absence of impact from local point or discrete nonpoint source pollution, or (2) the site is downstream of a significant point source or localized nonpoint source pollution area. There are five subprogram areas that make up the fixed station network:

1. The Department provides funding for the USGS ambient water quality network, which includes 61 stream sites at present monitored four to 12 times per year for a wide variety of physical, chemical and bacteriological constituents. Four sites are also sampled at less frequent intervals for a range of pesticides. Two sites on the Missouri River (St. Joseph

and Hermann) use continuous data sondes to measure nitrate concentrations from spring through fall.

USGS, in cooperation with the Department, recently published a study summarizing general water-quality conditions, long-term trends, and a network analysis of Missouri's long-term ambient water quality network sites based on monitoring data collected between 1993 and 2017 (Richards and Barr 2021). Trending results were summarized for 15 water quality analytes, and potential data gaps were identified in the network, as were potential site redundancies. The full publication and supporting data are available online at https://pubs.er.usgs.gov/publication/sir20215079.

2. Chemical monitoring is conducted by the Department at approximately 58 sites four to six times per year for nutrients, major ions, flow, temperature, pH, dissolved oxygen, and specific conductance.

3. Lake monitoring is largely conducted through UMC's SLAP and LMVP programs. SLAP samples an average of 65–70 lakes four times each summer for nutrients, phytoplankton chlorophyll (a surrogate for algal biomass), suspended solids, Secchi transparency, four algal toxins (i.e., microcystin, cylindrospermopsin, anatoxin, and saxitoxin), and a depth profile for dissolved oxygen and temperature. LMVP volunteers also sample approximately 65–70 lakes, but six to eight times per year for nutrients, phytoplankton chlorophyll, Secchi transparency, and two algal toxins (i.e., microcystin and cylindrospermopsin). SLAP only has one sampling site at the dam of each lake; some larger reservoirs may have multiple LMVP sites. For more information on UMC's lake monitoring programs, please visit: http://limnology.missouri.edu/projects.html. To get involved with LMVP, please visit the program's website at http://www.lmvp.org/.

4. Fish tissue monitoring is conducted to assess the health of aquatic biota as well as the human health risks associated with consuming fish. Thirteen fixed sites are monitored once every two years and samples are analyzed for mercury, chlordane, Polychlorinated Biphenyls (PCBs), and PFAS. Whole fish composite samples of either common carp or redhorse sucker are analyzed for metals, mercury, cadmium, selenium, several pesticides, and PCBs. Whole fish used for PFAS monitoring are dependent upon the waterbody but include redhorse suckers, carp, catfish, and bass species.

   Additional samples are collected from approximately 30 discretionary sites annually. Piscivorous fish sampled are preferably black bass species, but alternatively include walleye, sauger, northern pike, trout, flathead catfish, and/or blue catfish species. Tissue plug samples are collected from bass species and analyzed for mercury only. Fillet samples (skin off) may be collected from the remainder of bottom and non-bottom feeding species. Fillet samples are analyzed for metals, including mercury, cadmium, and selenium; those from bottom feeding species are also analyzed for a suite of organic compounds, including several pesticides and PCBs.

   Outside of Department-based sampling, MDC monitors another five to 20 sites each year that are considered popular sport fisheries and are of ecological value for Missouri's

citizens. Fish tissues are analyzed for pesticides, PCBs, mercury and other metals. Approximately three to five sites per year are sampled for PFAS. Sites are selected based on proximity to potential PFAS sources or they are based on concerns from staff and partners. These data are submitted to the Department and are used to assess the human health/fish consumption designated use for the water body.

5. Routine monitoring is conducted at approximately 20–30 discretionary sites annually to test for sediment contamination. Sediment samples are analyzed for a suite of heavy metals that individually or synergistically are known to be lethal or detrimental to fish, mussels, and other macroinvertebrates.

In addition to the sampling activities noted above, the Department's Division of State Parks conducts routine bacterial monitoring of swimming beaches during the recreational season. Results are posted on the Department website throughout the recreational season (April 1 – October 31; https://dnr.mo.gov/beaches).

Intensive and Special Studies

Intensive and special studies typically involve frequent monitoring of several sites in a small geographic area. These studies are driven by the need for site-specific water quality information. Intensive and special study findings may be used to develop water quality based NPDES permit limits, assist with compliance and enforcement activities, or guide resource management. The Department currently conducts several types of intensive and special studies:

- Wasteload Allocation Studies – Assess receiving waters of WWTFs to judge compliance with in-stream WQS and/or be used to develop water quality-based permit limits. Up to 10 wasteload allocation studies are completed annually.

- Toxics Monitoring – Assess receiving waters of coal mining and processing stations, metal mining operations, various industrial and municipal facilities and CAFOs. The need for this type of monitoring varies greatly from year to year. Sampling frequency depends on the intended use of data.

- Aquatic Invertebrate Biomonitoring – Macroinvertebrate communities are surveyed to evaluate concerns with either point source discharges, watershed-wide NPS problems, or discrete NPS areas such as active or abandoned mining sites. Reference sites are sampled periodically as controls to which targeted sites may be compared. Approximately 45–50 sites are sampled each year. Additionally, the Department contracted with the USGS in 2001 to conduct a study of aquatic invertebrate communities on the Missouri River. In 2020, the Department partnered with UMRBA to conduct a condition assessment on the Mississippi River, and USGS plans to initiate further macroinvertebrate monitoring on the Mississippi River beginning in 2023. The Department views these efforts as steps toward promoting a better understanding of fish and invertebrate communities of large rivers, and ultimately, developing biological criteria for the Missouri and Mississippi Rivers.

- Dissolved Oxygen Studies – Continuous data sondes are deployed where low dissolved oxygen levels are suspected. Sampling is carried out below selected hydropower dams with

historically low dissolved oxygen problems and in other areas where noncompliant discharges are suspected.

- Contract Studies – The Department typically has several active contracts for water quality monitoring at any given time. Most contracts support CWA Section 319 funded watershed projects, but past contractors have also completed Use Attainability Analyses (UAAs) as well as simple monitoring projects, specifically in cases where work entailed highly specialized skills and equipment, or when costs or work force limitations made it practical.

Screening Level Monitoring

In Missouri, screening level monitoring typically includes two primary strategies: Department-conducted low flow surveys and volunteer-based sampling efforts. Both strategies implement rapid stream assessment protocols that rely upon the consideration of visual evidence and the qualitative evaluation of aquatic biota. Some additional water chemistry sampling arising from inspections and complaint investigations may also be considered as screening level monitoring.

Low flow surveys are conducted by Department staff to assess streams that may potentially be influenced by WWTFs, mining activities, or landfills. These surveys are a rapid and inexpensive method of screening large numbers of streams for obvious water quality problems and for determining where more intensive monitoring is needed.

The Volunteer Water Quality Monitoring (VWQM) Program is a cooperative program between the Department, MDC, and the Conservation Federation of Missouri that is a subset of the Missouri Stream Team Program. Since its inception in 1993, nearly 12,000 citizens have attended roughly 1,000 water quality monitoring workshops held across the state by program staff. This has resulted in the submission of more than 48,000 separate data sheets for approximately 3,400 Missouri stream sites. Between FFYs 2020 and 2021, VWQM volunteers submitted a combined total of 402 macroinvertebrate data sets, 782 water chemistry data sets, 329 visual survey data sets, and 401 stream discharge data sets. In FFY 2020, volunteers spent approximately 3,691 hours in this endeavor and approximately 4,384 hours in FFY 2021.[2] The value to the state, in time spent by volunteers engaged in water quality monitoring, was estimated to be $95,818.36 in 2020 and $119,288.64 in 2021.[3]

A stream team is a group of citizen scientists organized to help learn and/or conduct hands-on stream conservation efforts. Approximately 262 new stream teams were formed between FFY 2020 and FFY 2021, bringing the total number of active stream teams to 5,062. Introductory water quality monitoring workshops were attended by 39 citizens in 2020 and 76 citizens in 2021.[4] After the Introductory workshop, many volunteers proceed on to at least one workshop for higher level training. Each level of training is a prerequisite for the next higher level, as is acceptable data submission. Levels 2, 3, and advanced Cooperative Stream Investigation (CSI)

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[2] In previous FFYs, volunteer hours have been calculated by multiplying the number of datasheets by an estimated volunteer collection time of 1.5 hours. Starting in FFY 2020, the estimated volunteer collection time was changed to 1 hour of collection per datasheet. This is an estimate minimum. Some volunteers may spend over 1 hour collecting data, depending on the datasheet and sampling location.

[3] These dollar amounts represent the volunteer hours multiplied by the value of volunteer time for Missouri ($25.96 and $27.21 for FFYs 2020 and 2021, respectively), according to the Independent Sector.

[4] The number of workshop participants in FFY 2020 was lower than normal due to the COVID-19 pandemic.

monitoring projects are accompanied by increasingly higher quality assurance and quality control stringency. Data submitted by volunteers of Level 2 or above may be used by the Department to establish baselines of water quality condition for particular streams, or to point out potential problems that need further investigation. Level 2 and higher volunteer monitors are required to return for a validation workshop a minimum of every three years in order to ensure their equipment and methods are up to date, and the data they are gathering has a high level of quality assurance. Volunteers may opt to either attend a Level 2 workshop again or attend a special Validation workshop in order to meet validation requirements.

Level 1 workshops were attended by 23 citizens in FFY 2020 and 22 in FFY 2021. Another 22 volunteers attended Level 2 workshops in FFY 2020, with none attending in 2021. Only one Level 3 audit was held between FFY 2020 and FFY 2021. Four CSI advanced monitoring projects were initiated in 2020 involving four specially trained volunteers; one CSI project was initiated in 2021 involving two specially trained volunteers. The VWQM program also facilitates Advanced Monitoring Projects (AMPs), which are concentrated citizen science projects that fall outside of the EPA approved chemical methods of official CSI projects. In FFY 2020, there was one AMP involving two specially trained volunteers; in FFY 2021, there were two AMPs involving three specially trained volunteers.

Level 2 volunteer data, or higher, is screened annually for physical, chemical, and biological parameters. If adequate data indicate water quality concerns or potential issues, then follow-up monitoring by the Department is scheduled. CSI level volunteers may be directly utilized for assisting in Departmental studies (e.g., watershed planning, TMDL implementation plans). For higher-level data to be utilized by the Department for 303(d) and 305(b) screening purposes, there must have been at least five chemical monitoring visits and/or three biological monitoring visits within a four-year period. For more information regarding the VWQM program, please visit the following websites: https://dnr.mo.gov/water/get-involved/volunteer-water-quality-monitoring-program; http://www.mostreamteam.org/water-quality-monitoring.html.

Probability-based Sampling

The Department's probability-based sampling is largely derived from the MDC Resource Assessment and Monitoring (RAM) Program, which performs aquatic macroinvertebrate, fish community, water quality, and habitat assessments at approximately 60 randomly selected stream sites annually (categorized as small to large rivers, stream orders 2–5). Each of Missouri's three ecological subregions (Figure 1) are monitored on an ongoing three-year rotation. Smaller watersheds identified as conservation priority geographies are also intensively sampled (up to 30 sites per watershed) on a long-term rotation. The RAM Program may occasionally focus on sampling streams for research projects outside of the random sampling rotation. MDC funds the RAM program at an estimated annual cost of $250,000.

Data generated via the RAM program is shared with the Department as part of a MOU between agencies. RAM data are used by MDC for trend monitoring in priority watersheds and tracking species ranges. The Department uses these data for statewide trend monitoring and CWA Section 305(b) reporting. MDC will use data to refer potentially impaired sites to the Department for more intensive monitoring. Metrics for assessing the biological integrity of macroinvertebrate communities are implemented statewide; however, fish community metrics have thus far only

been developed and validated for Ozark and Ozark border streams (Doisy et al. 2008). The Section 319 NPS program and its grantees also use RAM data for watershed planning purposes and to better understand overall watershed health.

On a smaller scale, the Department implements a randomized chemical monitoring program aimed to gather additional baseline or background data in priority watersheds and/or support 319 watershed management plans and projects. Focusing on individual drainage basins, this program involves quarterly collection of surface water samples from approximately ten randomly chosen sites for two to three years before monitoring efforts are shifted to another basin. Randomized basin-wide monitoring has been completed in the Sac River basin and is ongoing in the Niangua River basin for FFY 2020–2023.

Monitoring Program Evaluation

The four strategic water quality monitoring approaches (described above) contribute to the Department's ability to conduct a comprehensive assessment of state waters. Additional elements of the monitoring program, such as core and supplemental indicators, quality assurance, data management, data analysis and assessment, reporting, and general support and infrastructure, are discussed in detail in the Missouri's Water Quality Monitoring Strategy (MDNR 2022).

Monitoring has generally addressed critical point source assessments on an as needed basis. This has adequately characterized regional water quality to be largely unimpaired by point source discharges. However, the state's information needs have considerably increased and evolved over time. Of the 115,700 classified stream miles in the state, only 10.4% are considered assessed (having adequate monitoring data for reliable water quality characterization). Of these 12,013 assessed stream miles, 76.3 percent are considered monitored (i.e., data collected in the past seven years), whereas 23.7 percent were evaluated despite a lack of recent data. Information gaps and data needs are highlighted in Missouri's Water Quality Monitoring Strategy. Among the major monitoring needs identified in this strategy are: (1) the ecological characterization of the Mississippi, Missouri, and other large rivers; (2) the inventory, monitoring, and assessment of the state's wetlands; (3) bacterial monitoring of large reservoirs, biological criteria development for small reservoirs and lakes, and nutrient monitoring for both large and small reservoirs; (4) screening level surveys for intermittent streams; (5) additional chemical and biological monitoring of small (wadeable) streams; and (6) additional chemical monitoring of groundwater.

Data Acquisition and Information Sharing

The Department retrieves a large amount of raw data from the USGS and other state, federal, and municipal sources. All water quality data internally collected or externally retrieved by the Department are maintained in the Department's Water Quality Assessment (WQA) database. These data include information pertaining to water chemistry, bacterial concentrations, sediment toxicity, fish tissue contaminants, and fish and invertebrate communities. Water quality data in the WQA database is publically available online at https://apps5.mo.gov/mocwis_public/wqa/waterbodySearch.do.

Missouri uses the online WQA system for tracking and reporting water body use attainment information. The state's stream and lake network, WQS information, monitoring sites and

locations of permitted wastewater discharges and other potential pollutant sources can all be viewed within a Geographic Information System (GIS) environment. Much of these geospatial data are available to the public through the Department's web mapping application: https://modnr.maps.arcgis.com/home/index.html

Upon completion, the Department's ESP publishes bioassessment reports online as well as the macroinvertebrate sample data included in the reports. Both may be found on the Department's Biological Assessment webpage (https://dnr.mo.gov/water/hows-water/water-monitoring-data/quality-streams-rivers-lakes-wetlands/biological-assessments). Bioassessment reports synthesize the biological (macroinvertebrate), chemical, and habitat data collected from a waterbody. Online reports are updated when macroinvertebrate identifications are finalized.

Additional information regarding Missouri water quality and soil and water conservation programs can be found on the Department's website at https://dnr.mo.gov/water. Available information includes current and proposed NPDES permits, Missouri WQS, the latest LMD and 303(d) list, TMDLs, as well as opportunities for water resource conservation and grant funding.

Access to the Department's water quality data is relatively straightforward using online tools. Should additional assistance be needed, general requests for water quality information may be made by calling (573) 751-1300. Official requests for more specific information can be made by submitting an online form at https://dnr.mo.gov/open-records-sunshine-law-requests. Requests that cannot be easily accommodated by the online public database may require the Department to search published reports or water quality data files. If the report or data was generated by the Department, it can be sent to the requestor via electronic mail or regular mail (a hard copy for small reports and data files, or compact disks for larger data files). If the report or data file did not originate with the Department, the request may be passed on to the authoring organization. Requestors are also welcome to visit the Department office to view files directly.

Requests for viewing water quality data files should be sent to:

> Missouri Department of Natural Resources
> Water Protection Program
> ATTN: Mr. Robert Voss
> P.O. Box 176
> Jefferson City, MO 65102-0176
> Phone: 573-522-4505 | E-mail: robert.voss@dnr.mo.gov

C.2. Assessment Methodology

Water quality is judged by its conformance with Missouri's WQS. This section describes the Department's procedures for rating the quality of Missouri's waters under this approach, including an explanation of what types of data are used to determine designated use attainment, how that data is used, and how findings are reported. The assessment methodology is the process the Department uses for meeting requirements of CWA Sections 305(b) and 303(d), and is the basis for summary tables and appendices provided later in this document.

Information Used to Determine Designated Use Attainment
To determine whether or not each designated use is attained, water body-specific monitoring data and other relevant information are reviewed against applicable criteria. Monitoring data generated under the four strategic monitoring approaches mentioned in Section *C.1.* are key elements analyzed in the assessment process. The Department also utilizes data from many external sources that monitor for similar purposes and produce data of acceptable quality. Federal agencies collecting such data include USGS, EPA, USFS, USFWS, USACE, and the National Park Service. Other data contributors include resource agencies from the neighboring states of Illinois, Iowa, Kansas, Arkansas, and Oklahoma; several municipal entities; selected projects from graduate level researchers; MDC fish kill and pollution investigation reports; county public health departments; and data collected by wastewater dischargers as a condition of their discharge permits (although this data is not used in impairment listing purposes). For a complete list of data types and sources, please see Missouri's 2022 LMD (Appendix A).

Water Body Segments
Tables G and H of Missouri's WQS published in 10 CSR 20-7.031 contain classifications and use designations for all classified lakes and streams. Each individual water body listed in Tables G and H is considered an assessment unit. For each lake in Table G, there is only one listing unit. For streams, however, single systems may receive multiple classifications according to the character of their natural flow regime (e.g., permanent flow vs. intermittent flow); thus, there may be multiple listings or assessment units in Table H for any given stream. Water body segments for the Mississippi River reflect a 2003 interstate MOU between five states (Missouri, Illinois, Iowa, Wisconsin, Minnesota; UMRBA 2003). The purpose of the MOU is to enhance coordination of water quality assessments and management decisions on the Upper Mississippi River. Segmentation points are as follows: Des Moines River, Lock and Dam 21, Cuivre River, Missouri River, Kaskaskia River, and Ohio River. Results of UAAs and CWC rulings have affected the designation of recreational uses on the Mississippi River from the Ohio River to the Missouri River, resulting in further sub-segmentation. Both specific and general criteria may be applied to classified waters of the state. Unclassified waters are usually assessed against general (narrative) criteria and a subset of specific criteria commonly associated with acute toxicity to aquatic life. There are fewer available data on unclassified waters, and except for a few streams and lakes, these waters are normally not reported in the IR.

Water bodies are generally assessed individually. For each water body, all available data of acceptable quality is reviewed and assessed. That assessment may then be extrapolated to the entire spatial extent of the classified segment. The final extent of the assessment, however, may be adjusted to account for significant influences of point source discharges, substantial changes in land use and stream characteristics, or significant hydrologic and channel modifications. Multiple sample points are needed in order to adjust the final extent of an assessment. Occasionally, this results in assessments that are shorter than the full spatial extent of the classified water body.

C.2.1. Determining Designated Use Attainments

Unique sets of criteria are used to protect specific designated uses assigned to individual waters. Protective criteria include a range of physical, chemical and biological parameters. To determine

a level of attainment for a designated use, certain types of data must be collected to compare to protective criteria. Assessing most designated uses involves analyzing multiple parameters; however, exceeding a single criterion can be enough evidence to assess a use as impaired. All classified waters of the state, including large public lakes, are designated to be protected for whole body and/or secondary contact recreation, aquatic life, human fish consumption, and livestock and wildlife watering. A subset of these waters is protected for drinking water supply, irrigation, and industrial processes. This section describes how data and information are used by the Department to assess each of these designated uses. For each classified water body, and for each applicable designated use to that water body, Department assessments will be in one of four categories: (1) designated use fully attained; (2) designated use not attained; (3) designated use not assessed due to insufficient data; or (4) designated use not assessed.

Generally, a water body use assessment of “fully attained” suggests water quality is fair to excellent, whereas an assessment of “not attained” indicates poor water quality. To what extent resource quality is impacted depends on the degree to which the use is not attained. Waters with at least one designated use assessed as “not attained” are considered impaired. When possible, potential or known causes and sources of the impairment are described.

To make an assessment determination, data from the previous seven years are generally used. In some cases, however, older data may be used if the data remains reflective of present conditions.

For complete assessment methodology details, please see Missouri’s 2022 LMD (Appendix A). The LMD lists all data that may be used for performing water quality-based assessments and the applicable statistical methods for interpreting Missouri’s WQS. Prior to each listing cycle, the LMD goes through a stakeholder review process where it can be revised. Development of the 2022 Section 303(d) List and Section 305(b) report was based exclusively on the 2022 LMD.

Statistical Considerations

Specific statistical procedures are used to determine if exceedances resulting in non-attainment warrant a 303(d) listing. Each data type (e.g., bacterial, toxic chemical, bioassessment) undergoes a particular statistical procedure to determine compliance with WQS. Appendices B and C in the 2022 LMD list all statistical considerations and analytical tools the Department uses for listing waters as impaired. For each analytical tool, the specific decision rule and test procedure is provided. Procedures outlined in the LMD are based on data that meet quality assurance and control standards.

The Department uses a weight of evidence approach for assessing narrative criteria with numeric thresholds to determine the existence or likelihood of an impairment and the appropriateness of proposing a listing based on narrative criteria. For Tier Three waters, which includes outstanding state and national waters, no level of water quality degradation is allowed; therefore, assessment of these waters will generally compare current data to either historical data or data from segments that support water quality conditions that existed at the time the state’s antidegradation rule was promulgated (April 20, 2007). Based upon earlier guidance from EPA, the Department uses a burden-of-proof approach in its hypothesis testing that places emphasis on the null hypothesis. In other words, there must be very convincing data to accept the alternative hypothesis (that the water body is impaired).

Additional Approaches for Determining Designated Use Attainment

While specific designated use assessment procedures are contained in the LMD, there are several approaches that may be applied to all designated uses. Designated use protection may be accomplished in the absence of data, if the stream being assessed has similar land use and geology to a stream that has already received a water quality assessment. In such cases, the same rating must be applied to the stream being assessed, and this information may only be used for 305(b) reporting, not for 303(d) listing. Additionally, where models or other dilution calculations indicate noncompliance with allowable pollutant levels, waters may be added to Category 3B (see Section *C.2.2.*) and considered a high priority for additional water quality monitoring. For assessing narrative criteria for all designated uses, quantifiable data types can be used. Full attainment with WQS is achieved when stream appearance is typical of reference or control streams in that region of the state. For example, if water color measured using the platinum-cobalt method is significantly higher than an applicable reference stream, the water body would be judged to be in non-attainment of WQS.

The Department uses its best professional judgment for interpreting data that has been influenced by abnormal weather patterns and/or situations that complicate appropriate interpretation of the data. In some cases, data that would normally be adequate to assess a use is actually determined to be inadequate, and additional sampling is required to ensure a confident assessment.

C.2.2. Water Body Assignment Categories

Once all attainment decisions have been made for a given water body, it is categorized according to a degree of compliance with WQS. The Department utilizes a five-part category system which is helpful for reporting attainment of applicable WQS and for developing monitoring strategies that respond to resource issues identified in the assessment. The five-part categorization scheme is summarized below:

Category 1: All designated uses are fully attained.

Category 2: Available data indicate that some, but not all, designated uses are fully attained.

- **Subcategory 2A:** Available data suggest compliance with WQS. <u>No impairment suspected.</u>
- **Subcategory 2B:** Available data suggest noncompliance with WQS. <u>Impairment suspected.</u>

Category 3: There are insufficient data and/or information to assess any designated use.

- **Subcategory 3A:** Available data suggest compliance with WQS. <u>No impairment suspected.</u>
- **Subcategory 3B:** Available data suggest noncompliance with WQS. <u>Impairment suspected.</u>

Category 4: Available data indicate that at least one designated use is not attained, but a TMDL or a permit-in-lieu of a TMDL already exists or is otherwise not needed.

- **Subcategory 4A:** Any portion of the water is in non-attainment with WQS due to one or more discrete pollutants, and EPA has approved a TMDL.

Subcategory 4B: Any portion of the water is in non-attainment with WQS due to one or more discrete pollutants, and pollution control requirements (i.e., water quality based permits and/or voluntary watershed control plans) have been issued that are expected to adequately address the pollutant(s) causing the impairment.

Subcategory 4C: Any portion of the water is in non-attainment with WQS and a discrete pollutant or other property of the water cannot be pinpointed as a cause for the impairment.

Category 5: At least one discrete pollutant has caused non-attainment with WQS, and the water does not meet the qualifications for listing as Category 4. Category 5 waters are those placed on the 303(d) list.

C.2.3. Delisting Impaired Waters

Several factors may lead to removing a water body from the Section 303(d) list. Removal may occur when a TMDL addressing all pollutant pairs for a given water body has been completed and approved. In situations where an impairment is due solely to a permitted facility, it may be possible to revise the facility's permit to meet the targeted water quality criteria, this is known as a permit-in-lieu of a TMDL. Waters that recover from pollution may be delisted once water quality is assessed as meeting water quality criteria. Analytical tools used for delisting purposes are described in Missouri's 2022 LMD (see Appendix A). Waters can also be removed as a result of finding errors in the original assessment or listing, or due to changes in WQS.

C.2.4. Changes to the Listing Methodology Document

As noted earlier, the LMD may be revised every even numbered year, undergoing the same review and approval schedule as required for the Section 303(d) list. Through this iterative process, the present LMD has evolved to incorporate revisions related to reformatting and consolidation of information, inclusion of clarifying statements and additional detail, as well as minor corrections to grammar and tables, as needed or requested. During the 2022 cycle, few updates were made to the previous LMD. Several updates were made as a result of public comment. Revisions are summarized below. Please see the 2022 LMD for further details.

- Previously added language on assessing pH as a chronic criterion, which was pending WQS approval, was removed as the chronic pH criterion has become more involved than originally anticipated. Assessment of pH remains similar to that of dissolved oxygen.
- Corrections were made to general formatting, grammar, and spelling throughout.
- Minor edits to language were made to simplify and improve clarity throughout. Additional clarifications were made specifically related to fish tissue toxicity assessment, as well as to listing threatened waters.
- The Nutrient Criteria Implementation Plan previously added to Appendix F was shortened to only include excerpts relevant to assessing Missouri's Lake NNC.
- Citations and algal toxin thresholds were updated within Additional Lake Response Assessment Endpoints of the Lake NNC (Appendix F of the LMD).

C.3. Assessment Results

This section provides a summary of the Department's surface water assessment for the 2022 cycle. Included are overviews of the designated use distribution for Missouri's classified waters; assessment results per monitored and evaluated waters; probability-based surveys; lake trophic status and lake water quality trends; five-part categorization of surface waters; designated use attainment; and the Section 303(d) list and TMDL schedule.

All classified lakes and streams are identified in Tables G and H of Missouri's WQS. Classified waters are those with designated uses as defined in 10 CSR 20-7.031(1)(C). Table 2 summarizes designated use distribution across the state's classified waters.

Table 2. Distribution of designated uses across Missouri's classified waters.

Designated Use	Stream miles	Percent of Total	Lake acres	Percent of Total
Protection of Aquatic Life*	115,700	100	321,736	100
Warm water Habitat	115,700	100	321,736	100
Cool water Habitat	3,262	3	0	0
Cold water Habitat	298	<1	11,232	3
Human Health Protection – Fish Consumption	115,700	100	321,736	100
Whole Body Contact Recreation – A	6,284	5	261,417	81
Whole Body Contact Recreation – B	108,773	94	60,319	19
Secondary Contact Recreation	115,700	100	321,736	100
Livestock and Wildlife Watering	115,700	100	321,736	100
Drinking Water Supply	3,546	3	125,684	39
Industrial	1,643	1	6,959	2
Irrigation	115,700	100	321,736	100
Antidegradation				
Outstanding National Resource Waters	202	<1	0	0
Outstanding State Resource Waters	217	<1	270**	<1
Total Classified Waters	115,700		321,736	

**All waters have warm-water habitat aquatic life protections. Some waters have additional aquatic life protections for cool or cold water habitat. Thus, the sum of the individual aquatic life protections will exceed 100%.*
***Represents acreage for three marsh wetlands.*

Surface Water Monitoring and Assessment Summary

Designated use assessments were conducted using data derived from Departmental monitoring (described in Section *C.1.*), as well as data contributed by numerous federal, state, and municipal entities. Due to the state's extensive hydrological network, it is not feasible to collect a robust dataset on every classified water body in Missouri. Consequently, only a portion of all classified waters are monitored each assessment cycle.

The Department uses language such as monitored, evaluated, and unassessed to describe the extent of data availability for a water body. Monitored waters include streams and lakes for which sufficient water quality data for an assessment have been collected in the past seven years. Approximately 7.9 percent of all classified stream miles and 80.8 percent of all classified lake acres are considered monitored. Evaluated waters are those waters for which no data are available from the past seven years. In these cases, either older data are available, and are considered representative of current conditions; or they have geology and land use similar to nearby monitored waters and their water quality condition is assumed to be similar. Totals of 2.5 percent of all classified stream miles and 3.4 percent of all classified lake acres are considered evaluated. Unassessed waters are those waters lacking monitoring data, which also lack nearby waters with similar geology and land use that have been monitored. These represent the classified waters for which an accurate assessment of water quality condition is not possible. Thus, 89.6 percent of classified stream miles and 15.9 percent of classified lake acres remain unassessed. Overviews of the assessment decisions for classified streams and lakes (monitored and evaluated) are provided in Tables 3 and 4.

Table 3. Classified stream miles having been monitored, evaluated, and assessed (2014–2020).

Assessment Result	Monitored (miles)	Evaluated (miles)	Total Miles Assessed
Full Support of Assessed Uses (1, 2A, 2B)	4,310	2,233	6,542
Impaired for One or More Uses (4A, 4B, 4C, 5)	4,854	616	5,471
Inadequate Data for Use Assessment (3A, 3B)	303	103,477	--
Total Considered (1, 2A, 2B, 4A, 4B, 4C, 5)	--	--	12,013

Note: Waters in categories 3A and 3B are considered unassessed.

Table 4. Classified lake acres having been monitored, evaluated, and assessed (2014–2020).

Assessment Result	Monitored (acres)	Evaluated (acres)	Total Acres Assessed
Full Support of Assessed Uses (1, 2A, 2B)	43,202	3,531	46,733
Impaired for One or More Uses (4A, 4B, 4C, 5)	216,642	7,308	223,950
Inadequate Data for Use Assessment (3A, 3B)	2,479	48,546	--
Total Considered (1, 2A, 2B, 4A, 4B, 4C, 5)	--	--	270,683

Note: Waters in categories 3A and 3B are considered unassessed.

Probability-based Summary

The Department's probability-based summary is primarily informed by data generated through MDC's RAM program. Specifically, index of biological integrity scores from fish surveys (f-IBIs) are used to inform the percentage of streams fully supporting aquatic life use. Only f-IBI scores with accompanying habitat assessments are used. Habitat (QCPH1) scores are based on six metrics: (1) substrate quality, (2) channel disturbance, (3) channel volume, (4) channel spatial

complexity, (5) fish cover, and (6) tractive force and velocity. The QCPH1 score is the best overall indicator of habitat condition as assessed using MDC's RAM protocol to date. Data are excluded from analysis when stream habitat quality was too poor to fully support the fish community (QCPH1 score <0.39). Included f-IBI scores are, therefore, assumed to reflect stream water quality. F-IBI scores greater than 36 indicate aquatic life use is fully attained; scores of 29–36 indicate a community is suspected to be impaired but is at least partially attaining; and scores less than 29 suggest the community is impaired and aquatic life use is not attained. Final inclusion of f-IBI scores incorporate MDC staff's best professional judgment to ensure survey consistency and reliability.

The most recent probability-based summary was restricted to surveys of randomly selected sites on third, fourth, and fifth order streams in the Ozark subregion (Figure 1) collected between 2002-2010 and 2011-2018. This included 362 surveys, which represented approximately 3,235 miles of Ozark streams. Classified streams, third to fifth order in size, contribute to approximately 9,843 total stream miles in the Ozark subregion. The Department utilized f-IBI scores, as described above, to determine the percentages of stream surveys in which aquatic life use was fully attained (not impaired), partially attained (impairment suspected), or not attained (impaired). Extrapolated from these percentages were the estimated total miles of attaining, non-attaining, and suspect streams in the Ozark subregion. Results are summarized in Table 5.

Table 5. Probability-based summary of aquatic life use attainment in Ozark Streams.

Project Name	MDC RAM Program	
Type of Water Body	Stream	
Target Population	3rd to 5th Order, Ozark subregion	
Unit of Measurement	Classified stream miles	
Designated Use	Aquatic Life	
Indicator	Biological – Fish IBI	
Assessment Date	5/31/2023	
Survey Years	2002-2010	2011-2018
Size of Target Population # of surveys / represented miles	181 assessments / 2,341.2 miles	181 assessments / 1,424.9 miles
Attaining - percent, estimated miles	71.3%, 7,018 miles	61.9%, 6,093 miles
Non-attaining - percent, estimate miles	14.4%, 1,417 miles	11.0%, 1,083 miles
Suspect - percent, estimated miles	14.4%, 1,417 miles	27.1%, 2,667 miles

Lake Trophic Status

Trophic status is used to characterize a lake's water quality condition in response to nutrients. In Missouri, lake trophic status is classified based on thresholds of total chlorophyll (ChlT), total nitrogen (TN), total phosphorus (TP), and Secchi transparency (Secchi) established by Jones et al. (2008; Table 6). Chlorophyll is the green, photosynthetic pigment present in plants and plant-

like organisms such as algae. The amount of chlorophyll in a lake is dependent on the amount of algae in it, making chlorophyll a surrogate for algae and a good measure of water quality condition. Algae require nutrients, such as nitrogen and phosphorus, in order to grow. TN is the sum of nitrate, nitrite, ammonia, and organically-bound nitrogen. TP is composed of soluble phosphorus and phosphorus bound to organic and inorganic suspended sediment. In most Missouri reservoirs, phosphorus is the primary nutrient limiting algal growth (Petty et al. 2020). Secchi transparency, which can be impacted by both algae and suspended sediment, is a measure of how deep visual clarity can be maintained through the water column.

Following the classification method originally presented by Jones et al. (2008), the Department characterized the water quality condition of each Missouri lake as one of the following four trophic classes: oligotrophic, mesotrophic, eutrophic, or hypereutrophic. Along this trophic gradient, oligotrophic lakes tend to be the most pristine, having the highest water clarity with the lowest levels of nutrients and chlorophyll, while hypereutrophic lakes tend to be the most degraded, having the lowest water clarity with the highest levels of nutrients and chlorophyll. Lake nutrient concentrations result from both natural processes and anthropogenic influences; however, lake eutrophication is generally accelerated by human activities, particularly by those in agricultural and urban areas.

Table 6. Total chlorophyll (ChlT), total nitrogen (TN), total phosphorus (TP), and Secchi transparency thresholds for classifying lake trophic status from Jones et al. 2008.

Trophic Class	ChlT (µg/L)	TN (µg/L)	TP (µg/L)	Secchi (meters)
Oligotrophic	< 3	< 350	< 10	≥ 2.6
Mesotrophic	≥ 3 – 9	≥ 350 – 550	≥ 10 – 25	≥ 1.3 – < 2.6
Eutrophic	≥ 9 – 40	≥ 550 – 1200	≥ 25 – 100	≥ 0.45 – < 1.3
Hypereutrophic	≥ 40	≥ 1200	≥ 100	< 0.45

There are 549 classified designated-use lakes included in Missouri’s WQS. Approximately ten of these lakes are naturally occurring oxbow lakes within the floodplains of either the Missouri or the Mississippi Rivers. The rest of the lakes in the state are man-made reservoirs, or impoundments. In cooperation with UMC staff and the many volunteer water quality monitors involved in LMVP, at least 100 lakes across Missouri are monitored four or more times each summer. Monitoring includes analysis of chlorophyll (a surrogate for algal biomass), nutrients, suspended solids, and algal toxins, as well as physical measurements such as water clarity, dissolved oxygen, and temperature.

The 2022 lake water quality condition summary was updated to account for lake data collected through 2020. Trophic status was summarized for 241 lakes, of which 216 were classified designated-use lakes and 25 were unclassified general-use lakes. Only lakes with at least four years of data were included in the examination (Knowlton and Jones 2006). The Department considered all samples collected near the surface and at depth for calculating seasonal lake

values, but restricted samples to those collected between May 1 and September 30 at the deepest part of the lake or just upstream of a reservoir dam.[5] For each lake, trophic classes were determined per parameter for ChlT, TN, TP, and Secchi by comparing seasonal geometric means to the classification thresholds of Jones et al. (2008). The Department then considered the individual parameter-based trophic classes to determine the overall trophic status for the lake. In instances where there was majority agreement among the parameter-based trophic classes, the majority trophic class was designated as the overall trophic status of the lake. When there was no majority agreement, TP carried the most weight in making the final trophic determination.

Lakes are grouped based on natural physiographic regions sharing distinct combinations of soils, bedrock geology, topography, plant and animal distribution, and pre-settlement vegetation (Thom and Wilson 1980). These regions are very similar to the primary ecological sections of the classification system developed by Nigh and Schroeder (2002; Figure 2). Trophic status varies considerably between the physiographic regions. Regional and statewide trophic status overviews are summarized in Table 7. Oligotrophic lakes are found predominantly in the Ozark Highlands where the mostly forested landscape contributes fewer nutrients through NPS. No known oligotrophic lakes are found within the Plains region, where agriculture is widespread. Lakes in the Plains region are predominantly eutrophic and hypereutrophic. Trophic status classifications for individual lakes are listed in Appendix D.

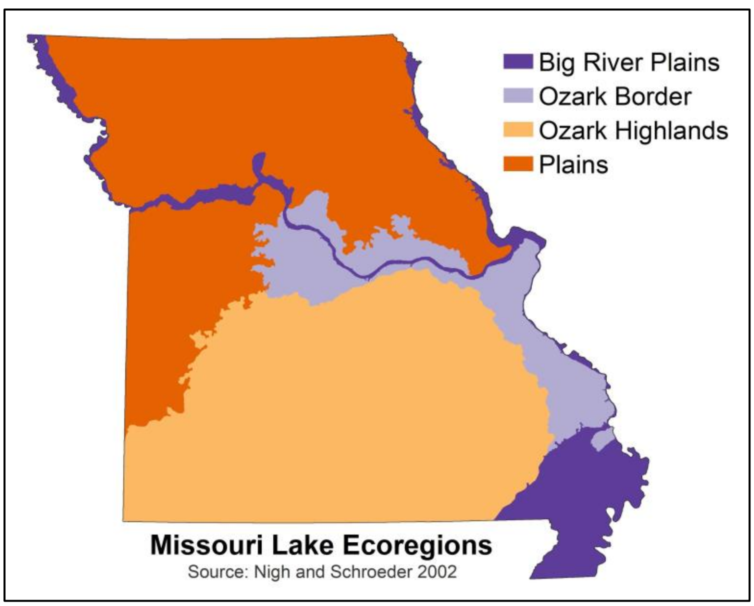

Figure 2. Missouri Lake Ecoregions

[5] Two lakes included in the lake condition summary have dams beyond the Missouri border. For these lakes, Bull Shoals Lake and Norfolk Lake, data were used from the first site falling within Missouri upstream of the dam.

Table 7. Overview of the trophic status distribution for Missouri lakes and reservoirs

Trophic Status	Plains #	Plains acres	Ozark Border #	Ozark Border acres	Ozark Highlands #	Ozark Highlands acres	Statewide Total* #	Statewide Total* acres
Oligotrophic	--	--	2	251	8	9,753	10	10,004
Mesotrophic	13	1,166	12	907	20	71,856	45	73,930
Eutrophic	113	106,019	25	1,251	17	76,787	157	184,327
Hypereutrophic	23	2,878	3	34	--	--	29	3,933
Total	149	110,063	42	2,443	45	158,396	236	270,902

*Excludes Big River Floodplain lakes.

Lake Nutrient Impairment and Trends [10 CSR 20-7.031(5)(N)]

In an effort to reduce eutrophication due to human activities, the Department has implemented NNC for all lakes that are waters of the state at least 10 acres in surface area, with the exception of natural oxbow lakes in the Big River Floodplain ecoregion. NNC include chlorophyll-a (Chl*a*) response impairment thresholds, as well as nutrient screening thresholds for Chl*a*, TN, and TP by ecoregion. At least three years of data is required for assessment to account for natural, climatic variation in nutrient levels (Jones and Knowlton, 2005). Geometric means are calculated for samples taken between May and September for each calendar year. If the yearly geometric mean of Chl*a* exceeds the Chl*a* response impairment threshold more than once in the last three years of available data, the lake is determined to be impaired. If a lake exceeds a nutrient screening threshold, it is deemed to be impaired only if one of five assessment endpoints are also exceeded in the same calendar year. The five assessment endpoints are:

- Occurrence of eutrophication-related mortality or morbidity events in fish and other aquatic organisms
- Epilimnetic excursions from dissolved oxygen or pH criteria
- Cyanobacteria counts in excess of 100,000 cells/mL
- Observed shifts in aquatic diversity attributed to eutrophication, and
- Excessive levels of mineral turbidity that consistently limit algal productivity.

Lakes listed in Table N of 10 CSR 20-7.031 have SSC to account for the unique characteristics of each water body; as such, the ecoregional NNC do not apply.

The Department evaluates individual lake trends for Chl*a*, Secchi, TN, TP, and total suspended solids (TSS). Lakes with either NNC or SSC may be trended. A minimum of ten years of data, with at least four surface-water (≤ 0.5 m) samples taken per year, is required in order to account for seasonal variability. Samples for any of the trended parameters must come from a site or sites representative of conditions at the lake's impoundment, and they must have been collected during the recreational season. Data for a lake's given parameter and year is then geometrically averaged, resulting in at least ten data points, one per year. A trendline is fit to these data using the Theil-Sen estimator method. A statistical test, such as the Mann-Kendall trend test, is used to

determine if the trend in data over time is statistically significant. This test is nonparametric, a type of test preferred due to its flexibility with normality in tested data. To be statistically significant, the test's associated p-value must be ≤ 0.05.

Significant Chl*a* trends may be used for 303(d) listings; other significant trends may be indicative of potential changes within the lakes and their watersheds. Listing decisions require the slope of the Chl*a* trendline to indicate a projected exceedance of the lake's Chl*a* criterion within five years of the last monitoring date. Confounding or exogenous variables, such as natural phenomena (e.g., rainfall, temperature) as well as evidence of anthropogenic nutrient enrichment, are also given consideration when making listing decisions.

Following nearly the same processes, the Department also evaluates ecoregional lake trends for Chl*a*, Secchi, TN, TP, and TSS with the only difference being that the data used for individually trended lakes are now aggregated by lake ecoregion. Ecoregions cannot be impaired, thus results of ecoregional trends, including those for Chl*a*, cannot be used for 303(d) listing purposes and are strictly suggestive toward broad trends in lake water quality.

During the 2022 cycle, trend analyses were performed on 64 lakes and three ecoregions (Appendix C). Of these lakes, 36 are considered impaired due to Chl*a* or nutrients. Although the Department predominantly lists lakes based on Chl*a*, per the LMD, additional parameters, like those trended outside of Chl*a*, may be considered as they relate to nutrient screening thresholds and eutrophication factors. TMDL studies have been developed to address impairments in three of the 36 impaired lakes. Hunnewell Lake was previously listed due to trend analysis indicating the lake would have exceeded the Chl*a* response impairment threshold within five years of the last date of data collection. With updated data, however, trend analysis no longer indicates such, and Hunnewell Lake was delisted for Chl*a* in the 2022 cycle.

Nineteen lakes had statistically significant nonparametric Chl*a* trend analyses. None of these, however, resulted in new listings. Fifteen lakes had statistically significant nonparametric Secchi trend analyses, 13 had such for TN, 13 for TP, and eight for TSS. In Appendix C, rows whose trend p-values are statistically significant are bolded. Negative trends for Chl*a* suggest a reduction in nutrients over time, as do negative trends for TN and TP with significant p-values.

While Appendix C provides a year of projected Chl*a* exceedance for each trended lake with ecoregional criteria, these years are only estimates based on current data trends. These can be greatly impacted by natural phenomena, such as climatic extremes or changes in land use. They are subject to change with the addition of more data. Some projected Chl*a* exceedance years are in the past or far future, while others are in the near future despite an "Improving" trend. The reported year is simply the year in which the trend's regression line crosses the lake's Chl*a* threshold, be it from below or above. If Chl*a* values are already exceeding the respective lake's impairment threshold and the trend is "Improving," the provided year instead indicates the projected year of Chl*a* attainment. Years of exceedance accompanied by p-values > 0.05 in Appendix C are not statistically significant and should not be considered reliable. Lakes with p-values > 0.05 will need additional data collection.

Controlling Pollution in Lakes

In Missouri, the three primary sources of NPS pollution include agriculture lands, urban areas, and, to a lesser extent, abandoned mine lands. The Department operates several programs that address water quality and habitat issues facing lakes and reservoirs in the state. While lake pollution may be addressed through regulatory controls, most activities are voluntary. As previously discussed, volunteer activities are typically addressed by the Department's NPS program and SWCP. For more information regarding these programs, see Section B.3.

In-lake management techniques that were previously funded under CWA Section 314 can now be funded under CWA Section 319 in the context of an appropriate NPS project. Several in-lake management techniques are eligible for CWA Section 319 funding, including water level drawdown, shading, biological controls (e.g., fish or insects), and planting or harvesting of aquatic plants. The Department also works with several watershed groups that strive to educate and inform landowners of threats to water resources in their area and promote land management practices that minimize NPS pollution. At least 77 watershed groups have been formed in Missouri to date.

The Department samples lake water quality as needed, but for the last thirty years, general monitoring has been primarily conducted under two specific programs: SLAP and LMVP. Together, these programs monitor over 100 lakes each year. Funding for SLAP and LMVP is provided under CWA Section 319. Outreach activities are a major component of LMVP.

TMDLs also help reduce pollution in Missouri lakes and reservoirs. Missouri's TMDL program began in 1999 and, as of 2022, eight studies have been completed for lakes to address reducing NPS pollution contributions. Appendix B includes a proposed schedule of future TMDL studies.

Five-Part Categorization of Surface Waters

Assessment results for Missouri's classified waters are summarized in Table 8 using the five-part categorization scheme. Please see Section *C.2.2* for category definitions.

Table 8. Classified stream mileage and lake acreage summarized across reporting categories

Water Body Type	Category									Total Assessed	Total Classified
	1	2A	2B	3A	3B	4A	4B	4C	5		
Streams (mi.)	93	5,037	1,412	102,004	1,776	1,045	28	471	3,927	12,013	115,700
Lakes (ac.)	0	16,150	30,583	49,413	1,612	2,672	0	0	221,278	270,683	321,736

Note: Waters in categories 3A and 3B are considered unassessed.

Designated Use Attainment Summary
Designated uses assigned to classified lakes and streams were individually assessed using site-specific information. Summarized results are shown in Tables 9 and 10. Each designated use (see Section *B.3.*) was assessed as either attained or not attained. Designated uses were not assessed for waters without existing data or for waters lacking sufficient data to accurately determine use attainment. During the 2022 cycle, a total of 12,013 stream miles and 270,683 lake acres were assessed for at least one designated use.

Table 9. Designated use attainment summary for classified streams.

Designated Use	Miles Fully Attained	Miles Not Attained	Miles Not Assessed	Total Miles in the state
General Use	1,993 (1.7%)	247 (0.2%)	113,460 (98.1%)	115,700
Protection of Aquatic Life (Warm water Habitat)	9,185 (7.9%)	2,241 (1.9%)	104,274 (90.2%)	115,700
Protection of Aquatic Life (Cool water Habitat)	2,345 (72.9%)	--	917 (27.1%)	3,262
Protection of Aquatic Life (Cold water Habitat)	101 (33.9%)	--	197 (66.1%)	298
Human Health Protection - Fish Consumption	2,145 (1.9%)	991 (0.8%)	112,564 (97.3%)	115,700
Whole Body Contact Recreation (A)	1,421 (22.6%)	1,507 (24.0%)	3,356 (53.4%)	6,284
Whole Body Contact Recreation (B)	892 (0.8%)	1,647 (1.5%)	106,234 (97.7%)	108,773
Secondary Contact Recreation	5,131 (4.4%)	319 (0.3%)	110,250 (95.3%)	115,700
Livestock and Wildlife Watering	3,167 (2.7%)	--	112,533 (97.3%)	115,700
Drinking Water Supply	1,822 (51.4%)	--	1,724 (48.6%)	3,546
Industrial Water Supply	--	--	1,643 (100.0%)	1,643
Irrigation	2,346 (2.0%)	--	113,354 (98.0%)	115,700

Table 10. Designated use attainment summary for classified lakes.

Designated Use	Acres Fully Attained	Acres Not Attained	Acres Not Assessed	Total Acres in State
General-Use	5,415 (1.7%)	16 (<0.1%)	316,305 (98.3%)	321,736
Protection of Aquatic Life (Warm water Habitat)	67,591 (21.0%)	198,442 (61.7%)	55,703 (17.3%)	321,736
Protection of Aquatic Life (Cold water Habitat)	--	2,119 (18.9%)	9,113 (81.1%)	11,232
Human Health Protection - Fish Consumption	169,109 (52.6%)	27,311 (8.5%)	125,316 (38.9%)	321,736
Whole Body Contact Recreation (A)	223,633 (85.5%)	--	37,784 (14.5%)	261,417
Whole Body Contact Recreation (B)	95 (0.2%)	--	60,224 (99.8%)	60,319
Secondary Contact Recreation	223,748 (69.5%)	--	97,988 (30.5%)	321,736
Livestock and Wildlife Watering	--	--	321,736 (100%)	321,736
Drinking Water Supply	24,914 (19.8%)	410 (0.3%)	100,360 (79.9%)	125,684
Industrial Water Supply	--	--	6,959 (100%)	6,959
Irrigation	--	--	321,736 (100%)	321,736

For each designated use identified as non-attained, there may be one or more potential contaminants causing impairment. Potential contaminants based on waters categorized as 4A, 4B, 4C, and 5 are listed in Tables 11 and 12. Summarized data are based on site-specific information. When a classified stream segment is impaired, the contaminant is typically assumed to impair the entire segment; however, if available data suggests only a portion of the segment is impaired, the shorter length is used to describe the impaired mileage. In contrast, when a lake's designated use is impaired, the lake's entire surface area is considered impaired per contaminant.

Table 11. Causes or types of designated use impairment assigned to classified streams.

Cause/Impairment Type	Impaired Stream Miles	Percent of Total Impaired Stream Miles
Bacteria (*E. coli*)	3,953	45.1%
Low Dissolved Oxygen	1,213	13.8%
Mercury in Fish Tissue	840	9.6%
Lead	568	6.5%
Fish Bioassessment	369	4.2%
Zinc	347	4.0%
Biological Indicators of Eutrophication	300	3.4%
Macroinvertebrate Bioassessment	294	3.4%
Cadmium	250	2.9%
Sediment/Siltation	161	1.8%
Chloride	127	1.4%
Habitat Assessment	92	1.0%
Unknown Cause(s)	53	0.6%
Sulfates	37	0.4%
Physical Substrate Habitat Alterations	32	0.4%
Water Temperature	26	0.3%
Total Dissolved Solids	21	0.2%
Solids, Suspended Bedload	18	0.2%
Ammonia, Total	16	0.2%
pH	15	0.2%
Copper	9	0.1%
Dissolved Oxygen Saturation	9	0.1%
Nickel	8	<0.1%
Chlordane in Fish Tissue	4	<0.1%
Total Nitrogen	4	<0.1%
Polycyclic Aromatic Hydrocarbons (PAHs)	4	<0.1%

Table 12. Causes or types of designated use impairment assigned to classified lakes.

Cause/Impairment Type	Impaired Lake Acres	Percent of Total Impaired Lake Acres
Chlorophyll (Total and Chlorophyll-a)	240,049	67.6%
Total Nitrogen	84,938	23.9%
Mercury in Fish Tissue	27,327	7.7%
Dissolved Oxygen Saturation	2,119	0.6%
Total Phosphorus	729	0.2%
Biological Indicators of Eutrophication	148	<0.1%
Pesticides (Atrazine)	44	<0.1%

Contaminants that cause designated use impairments originate from numerous sources. In some cases, a single source contributes multiple contaminants to the same water body. Impaired stream miles and lake acreages for each contaminant source are listed in Tables 8 and 9. Summarized

data are based on site-specific information. While contaminants can often be identified, monitoring limitations may make it difficult to pinpoint exact sources. Despite these limitations, various pollutant sources have been recognized as causing impairment of Missouri's waters.

Table 9. Contaminant sources for designated use impairments assigned to classified streams

Contaminant Source Category	Impaired Stream Miles	Percent of Total Impaired Stream Miles
Unspecified Nonpoint Source	3,276	37.4%
Mill and Mine Tailings	990	11.3%
Municipal Point Source	965	11.0%
Source Unknown	894	10.2%
Atmospheric Deposition (Mercury)	840	9.6%
Channelization	492	5.6%
Urban Runoff or Storm Sewers	486	5.5%
Industrial Point Source	211	2.4%
Agriculture	148	1.7%
Dam or Impoundment	102	1.2%
Habitat Modification*	89	1.0%
Industrial/Commercial Storm Sewers	86	1.0%
Other Recreational Pollution Sources	62	0.7%
Coal and Other Subsurface Mining**	61	0.7%
Flow Modification Impacts	29	0.3%
Natural Conditions	14	0.2%
Loss of Riparian Habitat	6	<0.1%
Streambank Modification/Destabilization	6	<0.1%
Drought-Related Impacts	6	<0.1%
Road/Bridge Runoff, Non-Construction	5	<0.1%
Rural or Residential Areas	4	<0.1%
Municipal, Urbanized High-Density Area	2	<0.1%

**excludes Hydromodification* ***includes Acid Mine Drainage*

Table 10. Contaminant sources for designated use impairments assigned to classified lakes

Contaminant Source Category	Impaired Lake Acres	Percent of Total Impaired Lake Acres
Unspecified Nonpoint Source	241,428	67.9%
Municipal Point Source	83,494	23.5%
Atmospheric Deposition (Mercury)	27,327	7.7%
Dam or Impoundment	2,119	0.6%
Urban Runoff or Storm Sewers	555	0.2%
Source Unknown	316	<0.1%
Rural or Residential Areas	106	<0.1%
Agriculture	9	<0.1%

Section 303(d) Assessment Results – List of Impaired Waters

Under Section 303(d) of the CWA, states are required to develop lists of impaired or threatened waters every two years. An impaired water body is defined as having chronic or recurring violations of numeric and/or narrative water quality criteria. List development is based on assessment methods described in Section *C.2.1.* and detailed in the LMD. Missouri's proposed Section 303(d) list is included in Appendix B.

The proposed 2022 Section 303(d) list of impaired waters (approved by the Missouri CWC) includes specific water body pollutants, their sources, and estimated impairment sizes. The proposed list reflects any deletions and additions of water body-pollutant pairs since the previous IR. Water body-pollutant pairs proposed to be removed from Missouri's previous Section 303(d) list are also provided in Appendix B. Waters are typically de-listed when new data shows water quality criteria are no longer exceeded, assessment methods change, initial listing errors are identified, EPA establishes or approves a TMDL, or EPA approves a permit-in-lieu of a TMDL.

In summary, the proposed 2022 Section 303(d) list of impaired waters includes 501 water body-pollutant pairs for both classified and unclassified waters. Approximately 5,000 stream miles and 223,950 lake acres are categorized as impaired by a specific pollutant. Pollutants most commonly identified include bacteria (138 listings), nutrients/chlorophyll (120), dissolved oxygen (70), mercury in fish tissue (65), and heavy metals in water or sediment (64). Most common known pollutant sources include NPS runoff (urban, rural, or unspecified NPS), atmospheric deposition, mining related sources, municipal WWTPs and other point sources.

Seventy-seven water body-pollutant pairs from the 2020 Section 303(d) list were proposed to be removed from the 2022 list. Delisting was often due to compliance with WQS, sometimes due to a change in WQS. In many cases, the return to compliance was attributable to restorative actions. Some were attributed to new assessment methods or erroneous listings. In most cases, however, the recovery reason was unknown. Refer to Appendix B for additional details on delisted waters.

Water bodies removed from this and previous Section 303(d) lists as a result of an approved TMDL or permit-in-lieu of a TMDL are listed in Appendix E. These waters, categorized as 4A, 4B, or 4C, are still considered impaired due to noncompliance with WQS. Twenty-eight water body-pollutant pairs attributed approved TMDLs were delisted in 2022. Appendix F lists potentially impaired water bodies that lack sufficient data to make that assessment conclusive.

TMDL Schedule

Under 40 CFR §130.7(b), states are required to submit a priority ranking schedule that identifies all waters targeted for TMDL development in the next two years. Each water body-pollutant pair listed on the Section 303(d) list must receive a clear priority ranking. EPA guidance encourages states to develop TMDLs for each water body-pollutant pair in a time frame no longer than 8 to 13 years from the time the pair was first listed; however, various factors are considered when determining actual TMDL development schedules.

On Missouri's 303(d) list, the Department ranks water body impairments as high, medium, or low priority for TMDL development. For water body impairments prioritized as high, the list also identifies a specific year for which the Department is targeting TMDL development. Water

body impairments ranked as medium or low priority are given a general range of years for which TMDL development may occur. When determining priority rankings, the Department considers a wide variety of factors, including, but not limited to, the designated use, pollution severity, pollutant type, data availability, modeling complexity, listing age, and watershed-approach suitability. The public is encouraged to provide feedback on the proposed TMDL prioritization and development schedule during the public comment period for the 303(d) list or any associated public availability sessions. Missouri's TMDL Prioritization Framework is available online at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

C.4. Wetlands Programs

Waters of the state identified as wetlands are those that meet criteria in the *USACE 1987 Wetlands Delineation Manual*. Missouri's current WQS lack designated uses specific to wetlands that are supported by numeric water quality criteria; however, as waters of the state, narrative criteria do apply to wetlands. Additional information on Missouri wetlands may be found at https://dnr.mo.gov/water/hows-water/state-water/surface-water/wetlands.

Wetlands meeting criteria in the *USACE 1987 Wetlands Delineation Manual* and considered jurisdictional waters of the United States are protected under CWA Sections 404 and 401. Persons seeking to alter wetlands through the discharge of "dredge or fill" materials and related impacts (e.g., installing culverts or rip-rap, rerouting streams, filling wetland for development purposes, restoration activities) must apply for a Section 404 permit with the USACE. In conjunction, the applicant must also obtain a Section 401 Water Quality Certification from the Department ensuring compliance with water quality requirements, including that WQS will not be violated and/or that appropriate mitigation steps will be taken when impacts are unavoidable.

The Department's WPP, under direction by the Missouri CWC and EPA, is working to establish WQS for wetlands. In 2013, the WPP was awarded a Wetland Program Development Grant by EPA, which helped establish a set of reference wetlands in Missouri that were subject to onsite water chemistry and biological sampling. Sampling on these reference wetlands has continued through the Wetland Water Quality Monitoring QAPP. Ultimately, it is intended that reference wetland information may be used for developing wetland WQS and establishing an IBI for wetlands.

The Department's Water Resources Center (WRC) administered the State Wetlands Conservation Plan, which encouraged the protection and restoration of wetlands and provided technical assistance to other agencies involved in wetland issues. With the assistance of other state and federal agencies, and a partnership with the University of Central Missouri, the Department completed several projects. These include studies assessing urban wetlands, identifying wetland types through image analysis, wetland nutrient monitoring, determining Missouri riparian wetland hydrology, and assessing specific wetland mitigation sites. Continuous monitoring of wetland hydrology was conducted at six sites in the state. These efforts were discontinued by 2020, but similar work may resume in future years.

Numerous state and federal wetland projects have been undertaken to protect and enhance Missouri's wetland resources. Together, MDC, USFWS and NRCS have protected more than

260,000 acres of wetlands through easements or purchases, restored more than 43,000 acres, and enhanced more than 41,000 acres in Missouri.

C.5. Public Health Issues

EPA asks states to provide information on public health issues, including information on drinking water supply, whole body contact recreation, and fish consumption advisories. The procedures for determining attainment of each use are provided in Section *C.2.1*. Please see Tables 9 and 10 for designated use support summaries related to these and other uses.

Drinking water supply usage is designated for 3,546 stream miles and 125,684 lake acres. This use is not supported in two lakes, Lewistown Lake (Lewis Co., 35 ac.) and Wyaconda Lake (Clark Co., 9 ac.). In both cases, the contaminant is atrazine due to local herbicide applications.

All classified streams and lakes are designated for fish consumption use. For streams, 991 miles are impaired due to contaminants in fish tissue. In all 14 stream impairments, the contaminant is mercury. Fifty classified lakes covering a total of 27,311 acres are also impaired by mercury in fish tissue. Mercury is known to make its way to surface waters through atmospheric deposition.

DHSS publishes an annual fish advisory and guide for eating fish in state waters. DHSS's advisory offers guidelines for two populations, all consumers and a sensitive population, which is defined as pregnant women, women of childbearing age, nursing mothers, and children younger than 13. In Missouri, guidelines vary according to water body, fish species and length. Contaminants of concern include mercury, chlordane, lead, and PCBs. For all consumers, recommendations vary from one meal per week to inconsumable for specific species from certain rivers. The most current complete fish advisory guide and fish advisory map viewer are available at https://health.mo.gov/living/environment/fishadvisory/.

During the recreational season, *E. coli* is sampled regularly at select designated swimming beaches in the state park system. Swimming is discouraged when the geometric mean of weekly samples exceeds 190 *E. coli* colonies per 100 mL of water. Sampling results and beach notifications may be viewed online at https://dnr.mo.gov/beaches.

PART D. GROUNDWATER MONITORING AND ASSESSMENT

Groundwater resources vary considerably in quantity and quality across Missouri. It is estimated that during normal weather cycles, 500 trillion gallons of drinkable groundwater is stored in Missouri's aquifers (Miller and Vandike 1997). Certain aquifers yield high volumes of quality water, whereas in some areas groundwater yields are low and/or contain water that is too mineralized for consumption. This section provides an overview of significant groundwater resources in the state, groundwater interactions with surface waters, groundwater quality, sources of groundwater contamination, and current monitoring efforts and protection programs.

D.1. Groundwater in Missouri

Approximately 40 percent of Missourians rely on groundwater for drinking water. Groundwater is the primary source of private and public drinking water in the Ozarks and the Southeastern Lowlands. The cities of St. Joseph, Independence, Columbia, and St. Charles use groundwater from the alluvial aquifer of the Missouri River. In the Plains region, many small communities are able to obtain adequate water from shallow alluvial wells near rivers or large creeks, and many individual households still rely on shallow upland aquifers despite small yields.

In the Ozarks, groundwater yields have historically been large and of excellent quality, as witnessed by the fact that many municipalities pump groundwater directly into their water supplies without treatment, unlike cities in other areas of the state. However, in a developed world, the geologic character of the Ozarks that supplies it with such an abundance of groundwater, namely its ability to funnel large amounts of rainfall and surface runoff to the groundwater system, can present problems for groundwater quality. This is because much surface water flows directly to groundwater through cracks, fractures or solution cavities in the bedrock, with little or no filtration. Contemporary contaminants from leaking septic tanks or storage tanks, or surface waters affected by domestic wastewater, animal feedlots, and other pollution sources can move directly into groundwater through these cavities in the bedrock.

As in the Ozarks, groundwater in the Southeast Lowlands (Mississippi Alluvial Basin) is abundant and of good quality. Public water supply wells in the southeast lowlands produce water from the alluvial aquifer and typically experience high levels of iron that require treatment and plant removal to improve the aesthetic quality of the water. Unlike the Ozarks, contaminants are filtered by thick deposits of sand, silt, and clay as they move through the groundwater system.

Throughout the state, shallow groundwater wells are subject to potential elevated levels of nitrate or bacteria and low levels of pesticides. Deep wells are generally unaffected by contaminants. Groundwater in the Central Plains of northern and western Missouri tends to be more mineralized and have taste and odor problems due to high levels of sulfur, chlorides, iron, manganese, etc.

In urban areas, alluvial aquifers of large rivers, such as the Missouri and the Meramec, which provide water to public water systems, have occasionally been locally contaminated by spills or improper disposal of industrial or commercial chemicals. Additional information on groundwater can be found through the Missouri Water Resources Plan (https://dnr.mo.gov/water/what-were-doing/water-planning/missouri-water-resources-plan).

D.2. Well Construction and Groundwater Quality

Well construction greatly influences the quality of water that is produced by a well. Therefore, state regulations include construction standards for both public and private wells. Public drinking water wells and private wells, constructed to meet these minimum standards, are deep, and properly cased and grouted. These wells rarely become contaminated. However, many private wells established prior to the development of construction standards are shallow or not properly cased. These wells can be easily contaminated by sources near the surface such as septic tanks, feedlots or chemical mixing sites near the well. Studies in Missouri have shown that two-thirds of wells contaminated by pesticides are less than 35 feet deep. The three most common problems in private wells are bacteria, nitrate, and pesticides. Water quality criteria for each of these pollutants can occasionally be exceeded in private wells.

D.3. Major Potable Aquifers in Missouri

Major aquifers providing drinkable water in Missouri are described below. Unconfined aquifers are those influenced by water table conditions and tend to yield greater amounts of water, but are also more easily contaminated by activities occurring at the land's surface. In confined aquifers, groundwater is overlain by a low permeable geologic material. Confined aquifers generally recharge more slowly than unconfined aquifers, but are better protected from surface contaminants.

Glacial Till Aquifer
This aquifer covers most of Missouri north of the Missouri River. Glacial till is an unsorted mixture of clay, sand, and gravel, with occasional boulders and lenses of sand or gravel. Loess, fine wind-blown silt, deposits of four to 122 feet deep cover the till. Loess deposits are deepest near the corridors of the Missouri and Mississippi rivers and decreases in depth as distance increases from these rivers (Thompson 1995). In some places, glacial till is underlain by sorted deposits of sand or gravel. Although this aquifer is unconfined, surface water infiltrates very slowly and groundwater yields are very small due to high-clay content. In scattered areas, till has buried old river channels that remain as large sand or gravel deposits that contain much more groundwater than the till. Some households rely on till deposits for drinking water, but it is generally inadequate as a source for large water needs. However, the buried river channels can provide enough water for large usages such as irrigation and public or municipal water supplies.

Alluvial Aquifer
Alluvial aquifers are the unconfined aquifers on the floodplains of rivers. In Missouri, the largest of these aquifers lie along the Missouri and Mississippi Rivers, reaching their widest extent in the Southeast Lowlands where they extend as far as 50 miles west of the Mississippi River. Many small communities north of the Missouri River use alluvial aquifers of nearby streams as their drinking water supply. The Missouri River alluvium supplies the cities of St. Joseph, Independence, and Columbia and sections of St. Charles County. In the Southeast Lowlands, most private water supplies and about 45 percent of people served by public water supplies use water from the alluvial aquifer. Agricultural irrigation is drawn from the alluvial aquifer.

Wilcox-McNairy Aquifers

These two aquifers lie beneath much of the alluvial aquifer of the Southeast Lowlands. They are in unconsolidated or loosely consolidated deposits of marine sands and clays of Tertiary and Cretaceous age (66 million and 100 million years old, respectively). Except where the McNairy Aquifer outcrops in the Benton Hills and along Crowley's Ridge, this aquifer is typically confined. The Wilcox Aquifer lies directly beneath the alluvial aquifer. The Wilcox and McNairy aquifers are hydrologically linked. They yield abundant amounts of good quality water and provide water for 55 percent of people served by public supplies in the Bootheel region. In the southeastern part of Stoddard County and most of New Madrid County, the McNairy Aquifer is too mineralized to be used for drinking water. Water from the Wilcox Aquifer can be high in iron and manganese, but the water quality is typically much better than from the overlying alluvial aquifer. These two aquifers appear to be unaffected by contaminants of human origin.

Ozark-St. Francois Aquifer

This aquifer covers most of the southern and central two-thirds of Missouri. It is composed of dolomites and sandstones of Ordovician and Cambrian age. Most of the aquifer is unconfined. This aquifer is used for almost all public and private drinking water supplies in this area of Missouri. Exceptions would include supplies in the St. Francois Mountains, such as Fredericktown and Ironton, where the aquifer has been lost due to geologic uplift and erosion, and near Springfield, where demand is heavy. In both these instances groundwater is supplemented with surface water sources.

Yields and water quality are typically very good. However, in many areas, the bedrock is highly weathered, containing many solution cavities, and can therefore transmit contaminated surface waters into the groundwater rapidly with little or no filtration. In southwest Missouri, the Ozark Aquifer is considered confined by overlying Devonian and Mississippian shale units. The Ozark continues westward for 80 miles or more as a potable water supply, serving the communities of Pittsburg, Kansas, and Miami, Oklahoma. However, the Ozark is also overlain by less permeable Pennsylvanian bedrock. The confined Ozark becomes too mineralized for drinking water within 20 to 40 miles of where the Pennsylvanian units begin. The unconfined portion of the Ozark-St. Francois aquifer is susceptible to contamination from surface sources. Increased urbanization and number of confined livestock facilities are threats to the unconfined portions of this valuable aquifer.

Springfield Aquifer

This aquifer covers a large portion of southwestern Missouri. It is composed of highly weathered Mississippian limestone. The aquifer is unconfined and surface water in many areas is readily transmitted to groundwater. Urbanization and confined livestock production affect this aquifer. Elevated nitrates and bacterial contamination are common problems in groundwater here.

D.4. Groundwater Contamination, Monitoring, and Protection

Contamination

Major sources of groundwater contamination in Missouri are generally associated activities such as agriculture; waste treatment, storage, and disposal; industrial and mining processes; and accidental spills. The Department has identified critical groundwater contamination sources within the state. Each source may result in one or more contaminants polluting groundwater.

Fertilizer and pesticide applications are among the main agricultural sources of nitrate and organic pesticides. Through waste treatment, storage, and disposal, it is land applications, underground storage tanks, and malfunctioning septic systems which may contribute nitrate, pathogens, and petroleum contaminants. Many other activities related to waste operations also cause groundwater contamination, such as from hazardous waste sites where organic pesticides, halogenated solvents, heavy metals, and radionuclides are contaminants. Other wastes from industrial facilities contaminate groundwater with nitrate, ammonia, pentachlorophenol, and dioxin. Mining operations can pollute groundwater with heavy metals. Saltwater intrusions from swimming pools and industry can increase the salinity of groundwater.

Monitoring

The Department's Environmental Remediation Program (ERP) and PDWB manage activities to protect groundwater and public health. The Department's WRC is responsible for water quantity issues and operates and maintains a network of more than 160 groundwater observation wells for monitoring Missouri's aquifers. While the Department does not directly administer a single statewide monitoring program for groundwater quality, such data are collected for specific projects and tracked by both the ERP and PDWB programs.

The ERP aims to protect human health and the environment from threats posed by hazardous wastes. One of this program's primary functions is to oversee cleanup of contaminated sites, which may be addressed by one of the Department's regulatory programs such as the Comprehensive Environmental Response Compensation and Liability Information System, Leaking Underground Storage Tanks, and Resource Conservation and Recovery Act. Additionally, the program's Federal Facilities Section provides oversight and review of investigations, management and remediation of hazardous substances at facilities currently or previously owned or operated by the Department of Defense or Department of Energy. Furthermore, contaminated sites may be subject to regulation if they are one of the National Priorities Listed sites or if the contaminants reside on state lands. Cleanup typically involves underground injections into the aquifer. More information regarding the ERP may be found at https://dnr.mo.gov/about-us/division-environmental-quality/environmental-remediation-program.

The PDWB ensures all public water systems provide safe drinking water. Public water systems utilizing groundwater may test supply wells for compliance. These data are reviewed and stored in the PDWB's database.

While the WRC focuses on water quantity issues regarding availability and usage, it conducted a statewide screening level survey for pesticides in shallow groundwater wells from 2001 to 2006 (Baumgartner 2006) to determine if agricultural pesticides entered groundwater as a result of normal field application. The survey focused primarily on atrazine, simazine, alachlor, and metolachlor. Samples were collected from 190 wells, of which 186 showed no measurable levels of pesticide. Of the four wells that showed some level of pesticide contamination, no samples contained concentrations above EPA's listed MCLs at that time.

PART E. PUBLIC PARTICIPATION

In accordance with federal CWA regulation and RSMo 644.036.5, the Department provides several opportunities for the public to participate in the development of the Section 303(d) list. The LMD also receives public review and is approved pursuant to 10 CSR 20-7.050.

The public comment period for the proposed 2022 Section 303(d) List opened on October 13, 2022, and closed January 18, 2023. The public notice was posted in eight major newspapers circulated primarily in and around the cities of St. Louis, Kansas City, St. Joseph, Springfield, Kirksville, Columbia, Jefferson City and Cape Girardeau. Documents were posted on the Department's Section 303(d) website at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters throughout the public comment period. Assessment worksheets for proposed water body listings were also posted on the webpage. Public availability meetings were held at the Lewis and Clark State Office Building in Jefferson City on November 16 and December 13, 2022. A public hearing on the proposed 2022 Section 303(d) list was held before the CWC on January 11, 2023.

Summaries of the public availability meetings were posted on the Department's Section 303(d) website and have been included, along with all administrative records, in the 2022 Section 303(d) list package submitted to EPA. During the meetings, impaired water body listing decisions were discussed with stakeholders and other parties in attendance. The Department responded to all questions and comments received during the public notice period. Responses to public comments regarding the Section 303(d) list are included in Appendix G. Missouri's 2022 Section 303(d) list was approved by the CWC during a public meeting held on April 12, 2023.

The present LMD went through the public notice process and was approved by the CWC on January 7, 2021. The 2024 LMD was placed on public notice from February 24, 2023, through April 25, 2023, and will go before the CWC for approval on July 12, 2023.

REFERENCES

Baumgartner, S.D. 2006. Results of monitoring shallow groundwater in Missouri for four agricultural pesticides, 2001-2006. Final Report to U.S. EPA Region VII. Missouri Department of Natural Resources - Water Resources Center.

Brookshire, C.N. 1997. Missouri state water plan series volume III, Missouri water quality assessment. Missouri Department of Natural Resources, Division of Geology and Land Survey. Water Resources Report No. 47.

Doisy, K.E., Rabeni, C.F., Combes, M.D., and R.J. Sarver. 2008. Biological criteria for stream fish communities of Missouri. Final Report to the Environmental Protection Agency. Region 7. Kansas City, KS. February 12, 2008.

Epperson, J.E. 1992. Missouri wetlands: a vanishing resource. Missouri Department of Natural Resources, Division of Geology and Land Survey.

Jones, J.R. and M.F. Knowlton. 2005. Chlorophyll response to nutrients and non-alga seston in Missouri reservoirs and oxbow lakes. Lake and Reservoir Management, 21(3):361-371.

Jones, J.R., Obrecht, D.V., Perkins, B.D., Knowlton, M.F., Thorpe, A.P., Watanabe, S., and R.R. Bacon. 2008. Nutrients, seston, and transparency of Missouri reservoirs and oxbow lakes: an analysis of regional limnology. Lake and Reservoir Management, 24:155-180.

Karl, T.R., J.M. Melillo, and T.C. Peterson. 2009. Global climate change impacts in the United States. United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

Knowlton, M.F., and J.R. Jones. 2006. Natural variability in lakes and reservoirs should be recognized in setting nutrient criteria. Lake and Reservoir Management, 22(2): 161-166.

Miller, D.E., and J.E. Vandike. 1997. Missouri state water plan series volume II, groundwater resources of Missouri. Missouri Department of Natural Resources Division of Geology and Land Survey. Water Resources Report No. 46.

MDNR. 2018. Nutrient Criteria Implementation Plan. Missouri Department of Natural Resources, Division of Environmental quality, Water Protection Program. Approved by the Missouri Clean Water Commission. July 27, 2018.

MDNR. 2021. Proposed methodology for the development of the 2022 Section 303(d) List in Missouri. Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program. Approved by the Missouri Clean Water Commission. January 7, 2021.

MDNR. 2022. A proposal for a water quality monitoring strategy for Missouri, FFY 2021-2026. Missouri Department of Natural Resources Water Pollution Control Program. Draft Document.

Nigh, T.A., and W.A. Schroeder. 2002. Atlas of Missouri ecoregions. Missouri Department of Conservation.

Petty, E.L., Obrecht, D.V., and R.L. North. 2020. Filling in the flyover zone: high phosphorus in Midwestern (USA) reservoirs results in high phytoplankton biomass but not high primary productivity. Frontiers in Environmental Science, 8:111.

Pflieger, W.L. 1997. Fishes of Missouri. Missouri Department of Conservation. Jefferson City, MO.

Raeker, G., Fleming, J., Morris, M., Moser, K., and T. Treiman. 2010. Missouri's forest resource assessment and strategy. Missouri Department of Conservation and United States Department of Agriculture Forest Service.

Richards, J.M., and M.N. Barr. 2021, General water-quality conditions, long-term trends, and network analysis at selected sites within the Ambient Water-Quality Monitoring Network in Missouri, water years 1993–2017: U.S. Geological Survey Scientific Investigations Report 2021–5079, 75 p., https://doi.org/10.3133/sir20215079.

Sowa, S.P., Diamond, D.D., Abbitt, R., Annis, G., Gordon, T., Morey, M.E., Sorenson, G.R., and D. True. 2005. A gap analysis for riverine ecosystems of Missouri. Final Report, Submitted to the USGS National Gap Analysis Program.

Thom, R.H. and J.H. Wilson. 1980. The natural divisions of Missouri. Transactions of the Missouri Academy of Science. 14:9-23.

Thompson, T. L. 1995. The Stratigraphic Succession in Missouri. Vol. 40. Missouri Department of Natural Resources, Division of Geology and Land Survey.

United States Census Bureau. 2022. State and County Quick Facts website, accessed February, 2023. https://www.census.gov/quickfacts/fact/table/MO/PST045222#PST045222.

APPENDIX A - METHODOLOGY FOR THE DEVELOPMENT OF THE 2022 SECTION 303(D) LIST

Methodology for the Development of the 2022 Section 303(d) List in Missouri

Clean Water Commission Approved

January 7, 2021

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program

Table of Contents

I. Citation and Requirements

Citation of the Clean Water Act

The Missouri Department of Natural Resources (MoDNR) is responsible for the implementation and administration of the Federal Clean Water Act (CWA) in Missouri. Pursuant to Section 40 of the Code of Federal Regulations (CFR) 130.7, states, territories and authorized tribes must submit biennially to the United States Environmental Protection Agency (EPA) a list of waters with limited (impaired) water quality, any known pollutants causing the impairments, and the priority ranking of waters targeted for Total Maximum Daily Load development. Under federal regulation of 40 CFR 130.7, states, territories, and authorized tribes are also required to submit to EPA a written methodology document describing the entity's approach in considering, and evaluating existing readily available data used to develop their 303(d) list of impaired water bodies. The Listing Methodology Document (LMD) must be submitted to EPA in the same year as the Section 303(d) list. While EPA does not approve or disapprove the listing methodology, the agency does consider the methodology during its review of the state's 303(d) impaired waters list and its determination to list or not to list waters.

Following approval by the Missouri Clean Water Commission (CWC), the Section 303(d) list, the 305(b) report, and the assessment data on the remaining waters of the state, is submitted to EPA through EPA's Assessment, Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS). This fulfills Missouri's biennial submission requirement of an integrated report as required under Sections 303(d), 305(b) and 314 of the CWA.

U.S. EPA Guidance

In 2001, the Office of General Counsel and the Office of Wetlands, Oceans, and Watersheds developed a recommended framework to assist EPA regions in the preparation of their approval letters for the States' 2002 Section 303(d) list submissions. This was to provide consistency in making approval decisions, along with guidance for integrating the development and submission of the 2002 Section 305(b) water quality reports and Section 303(d) list of impaired waters.[6]

The following sections provide an overview of EPA Integrated Report Guidance documents, available from EPA's website (https://www.epa.gov/tmdl/integrated-reporting-guidance-under-cwa-sections-303d-305b-and-314):

The "2002 Integrated Water Quality Monitoring and Assessment Report Guidance" was the first document EPA provided to the states, territories, and authorized tribes with directions on how to integrate the development and submission of the 2002 Section 305(b) water quality report and Section 303(d) list of impaired waters.

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[6] Additional information can be obtained from EPA's website: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/guidance.cfm).

At that time, EPA guidance recommended that states, territories and authorized tribes submit a combined integrated report satisfying the CWA requirements for both the Section 305(b) water quality report and Section 303(d) list. The final 2002 Integrated Report was to include:

- Delineation of water quality assessment units based on the National Hydrography Dataset (NHD);
- Status of and progress toward achieving comprehensive assessments of all waters;
- Water quality standards (WQS) attainment status for every assessment unit;
- Basis for the WQS attainment determinations for every assessment unit;
- Additional monitoring that may be needed to determine WQS attainment status and, if necessary, to support development of TMDLs for each pollutant/assessment unit combination;
- Schedules for additional planned monitoring for assessment units;
- Pollutant/assessment unit combinations still requiring TMDLs; and
- TMDL development schedules that reflect the priority ranking of each pollutant/assessment unit combination.

The 2002 EPA guidance described the requirements of the CWA Section 303(d), under which states, territories, and authorized tribes are required to detail the methodology used in developing their 303(d) list. EPA's guidance recommended states provide: (1) a description of the methodology used to develop Section 303(d) list; (2) a description of the data and information used to identify impaired and threatened waters; (3) a rationale for not using any readily available data and information; and (4) information on how interstate or international disagreements concerning the list are resolved. Lastly (5), EPA recommended that "prior to submission of its Integrated Report, each state should provide the public the opportunity to review and comment on the methodology." In accordance with EPA guidance, the Department continues to review and update the LMD every two years. Once updated, the LMD is made available to the public for review and comment. Following the 60 day public comment period, the Department responds to public comments and provides EPA with a summary of all comments received and Department responses given.

In July 2003, EPA issued new guidance entitled "Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act." This guidance gave further recommendations about listing of 303(d) and other waters.

In July 2005, EPA published an amended version entitled "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act" (US EPA 2005; see Appendix A for excerpt).

In October 2006, EPA issued a memorandum entitled "Information Concerning 2008 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions." This memorandum serves as EPA's guidance for the 2008 reporting cycle and beyond. This guidance recommended that each state uses a five-part categorization scheme and provides a

comprehensive description of the WQS attainment status of all segments within the state (reference Table 1). The guidance also defined a "segment" as being synonymous with the term "assessment unit" used in previous Integrated Report Guidance documents. Overall, the selected segmentation approach should be consistent with the state's WQS and be capable of providing a spatial scale that is adequate to characterize the WQS attainment status for the segment.

The 2006 EPA guidance recommended all waters of the state be placed into one of the five categories described below:

Table 1. Placement of Waters within the Five Categories in EPA's Assessment, Listing and Reporting Guidance

Category 1	All designated uses are fully maintained. Data or other information supporting full use attainment for all designated uses must be consistent with the state's LMD. The Department will place a water in Category 1 if the following conditions are met: • The water has physical, chemical (at a minimum, water temperature, pH, dissolved oxygen, ammonia, total cobalt, and total copper for streams; and pH, dissolved oxygen, total nitrogen, total phosphorus, Secchi depth, suspended solids, chlorophyll-a, and algal toxins for lakes), biological, and pathogenic water quality data (at a minimum, *Escherichia coli*, hereafter *E. coli*,) that indicates attainment of WQS. • The level of mercury and other contaminants in fish tissues used for human consumption indicates attainment of WQS. Only samples of higher trophic level species (largemouth, smallmouth and spotted bass, sauger, walleye, northern pike, trout (rainbow and brown trout), striped bass, white bass, flathead catfish and blue catfish) will be used for assessment of mercury. • The water is not rated as "threatened."
Category 2	One or more designated uses are fully attained but at least one designated use has inadequate data or lacks information to make a use attainment decision consistent with the state's LMD. The Department will place a water in Category 2 if *at least one* of the following conditions are met: • There is inadequate data for water temperature, pH, dissolved oxygen, ammonia, total cobalt or total copper in streams to assess attainment with WQS or inadequate data for total nitrogen, total phosphorus, chlorophyll-a, or Secchi depth in lakes. • There is inadequate *Escherichia coli (E. coli)* or fecal coliform bacteria data to assess attainment of the whole body contact recreational use. • There is insufficient fish tissue data available to assess attainment of the fish consumption use. Category 2 waters will be placed in one of two subcategories:

	2A. Waters will be placed in this subcategory if available data, using best professional judgement, <u>suggests compliance</u> with numeric water quality criteria in Missouri's WQS (10 CSR 20-7.031) or other quantitative thresholds for determining use attainment. **2B.** Waters will be placed in this subcategory if the available data, using best professional judgment, <u>suggests noncompliance</u> with numeric water quality criteria in Missouri's WQS or other quantitative thresholds for determining use attainment, and these data are insufficient to support a statistical test or to qualify as representative. Category 2B waters will be given high priority for additional water quality monitoring.
<u>Category 3</u>	Water quality data are inadequate to make a use attainment decision consistent with the state's LMD for *any* of the designated uses. The Department will place a water in Category 3 if data are lacking to support a statistical test or to qualify as representative for assessing any of the designated uses. Category 3 waters will be placed in one of two subcategories: **3A.** Waters will be placed in this subcategory if available data, using best professional judgment, <u>suggests compliance</u> with numeric water quality criteria in Missouri's WQS (10 CSR 20-7.031) or other quantitative thresholds for determining use attainment. Category 3A waters will be tagged for additional water quality monitoring but given lower priority than Category 3B waters. **3B.** Waters will be placed in this subcategory if the available data, using best professional judgment, <u>suggests noncompliance</u> with numeric water quality criteria in Missouri's WQS or other quantitative thresholds for determining use attainment. Category 3B waters will be given high priority for additional water quality monitoring.
<u>Category 4</u>	State WQS or other criteria, as per the requirements of Appendix B & C of this document, are not attained but a TMDL study is not required. Category 4 waters will be placed in one of three subcategories: **4A.** EPA has approved a TMDL study that addresses the impairment. The Department will place a water in Category 4A if **both** the following conditions are met: • Any portion of the water is rated as being in non-attainment with WQS or other criteria, as explained in Appendix B & C of this

	document, due to one or more discrete pollutants or discrete properties of the water,[7] and • EPA has approved a TMDL for the pollutant(s) causing non-attainment. **4B.** Water pollution controls required by a local, state or federal authority are expected to correct the impairment in a reasonable period of time. The Department will place a water in Category 4B if **both** the following conditions are met: • Any portion of the water is rated as being in non-attainment with WQS or other criteria, as explained in Appendix B & C of this document, due to one or more discrete pollutants or discrete properties of water; and • A water quality based permit that addresses the pollutant(s) causing the designated use impairment has been issued, and compliance with the permit limits will eliminate the impairment; or other pollution control requirements have been made that are expected to adequately address the pollutant(s) causing the impairment. This may include implemented voluntary watershed control plans as noted in EPA's guidance document. **4C.** Any portion of the water is rated as being in non-attainment with WQS or other criteria, as explained in Appendix B & C of this document, and a discrete pollutant or discrete property of the water[3] does not cause the impairment.
Category 5	At least one discrete pollutant has caused non-attainment with WQS or other criteria, as explained in Appendix B & C of this document, and the water does not meet the qualifications for listing as either Categories 4A or 4B. *Category 5 waters are those that are candidates for the state's 303(d) list.*[8] If a designated use is not supported and the segment is impaired or threatened, the fact that a specific pollutant is not known does not provide reason for excluding a segment from Category 5. Category 5 waters will be placed in one of two subcategories: **5.** These segments must be listed as Category 5, unless the state can demonstrate that no discrete pollutant(s) causes or contributes to the impairment. Pollutants causing the impairment will be identified through the 303(d) assessment and listing process before a TMDL study is written. The TMDL should be written within the time frame specified by EPA guidance for TMDL development, and as it fits within the state's TMDL prioritization schedule.

[7] A discrete pollutant or a discrete property of water is defined here as a specific chemical or other attribute of the water (such as temperature, dissolved oxygen, or pH) that causes designated use impairment and that can be measured quantitatively.
[8] The proposed state 303(d) list is determined by the Missouri Clean Water Commission. The final list is determined by EPA.

	5-alt. A water body assigned to 5-alt is an impaired water lacking a completed TMDL but, because an alternative restoration approach is being pursued, has been assigned a low priority for TMDL development. This subcategorization increases public transparency that the state is pursuing restoration activities on such waters to achieve attainment of WQS. This subcategory also facilitates tracking alternative restoration approaches of 303(d) listed waters in priority areas.
Threatened Waters	A water body is considered "threatened" when it is currently attaining all designated uses, but the data shows an inverse (time) trend in water quality for a discrete pollutant. In such waters, a statistically significant data trend indicates that the designated use will not be met before the next listing cycle.".. A threatened water will be treated as an impaired water and be placed in the appropriate category (4A, 4B, or 5).

In subsequent years, EPA has provided additional guidance, but only limited new supplemental information has been provided since the 2008 cycle.

In August 2015, the EPA provided draft guidance that would include a Category 5-alternative (5-alt; reference Table 1). Additional information can be found at EPA's website: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/guidance.cfm.

Missouri has additional requirements for the LMD in the Code of State Regulations 10 CSR 20-7.050. No requirement outlined in 10 CSR 20-7.050 conflict with EPA's guidance.

II. The Methodology Document

A. Procedures and Methods Used to Collect Water Quality Data

- Department Monitoring

The major purposes of the Department's statewide water quality monitoring program are to:

- characterize background or reference water quality conditions;
- better understand daily flow events, seasonal water quality variations, and their underlying processes;
- characterize aquatic biological communities;
- assess trends in water quality;
- characterize local and regional effects of point and nonpoint sources pollutants on water quality;
- check for compliance with WQS and/or wastewater permit limits; and to
- support development of mitigative strategies, including TMDLs, to restore impaired waters to attainment of WQS.

- Coordination with Other Monitoring Efforts in Missouri

To maximize efficiency, the Department routinely coordinates monitoring activities with other agencies to avoid overlap, and to give and receive feedback on monitoring design. Data from other sources are used for meeting the same objectives as Department-sponsored monitoring. The data must fit the criteria described in the data quality considerations section of this document. The agencies most often involved are the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (USACE), EPA, the Missouri Department of Conservation (MDC), and the Missouri Department of Health and Senior Services (DHSS). The Department also tracks the monitoring efforts of the National Park Service; the U.S. Forest Service; several of the state's larger cities; the states of Oklahoma, Arkansas, Kansas, Iowa, and Illinois; and graduate level research conducted at Missouri universities. For those wastewater discharges where the Department has required instream water quality monitoring, the Department may also use monitoring data acquired by the wastewater dischargers as a condition of discharge permits issued by the Department. In 1995, the Department also began using data collected by volunteers that have passed Volunteer Water Quality Monitoring Program Quality Assurance/Quality Control (QA/QC) tests.

- Existing Monitoring Networks and Programs

The following are water quality monitoring activities presently conducted in Missouri:

1. Fixed Station Network

a) Objective - To better characterize background or reference water quality conditions; to better understand daily flow events, seasonal water quality variations, and their underlying processes; to assess trends; and to check for compliance with WQS.

b) Design Methodology - Sites are chosen based on one of the following criteria:
   - Site is believed to have water quality that represents many similarly sized streams in the region due to likeness in watershed geology, hydrology, and land use, as well as an absence of impact from significant point or discrete nonpoint source pollution.
   - Site is downstream of a significant point or discrete nonpoint source pollution area.

c) Number of Sites, Sampling Methods, Sampling Frequency, and Parameters:
   - MoDNR/USGS cooperative network monitors approximately 70 sites statewide, collecting horizontally and vertically integrated grab samples four to twelve times per year. Samples are analyzed for major ions (e.g., calcium, magnesium, sulfate, and chloride), nutrients (e.g., phosphorus and nitrogen), temperature, pH, dissolved oxygen, specific conductance, bacteria (e.g., *E. coli* and fecal coliform) and flow on all visits; for suspended solids and heavy metals two to four times annually; and for pesticides six times annually at four sites.
   - MoDNR/University of Missouri-Columbia's lake monitoring network has monitored about 249 lakes since 1989. More than 75 lakes are monitored each year. Each lake is usually sampled a minimum of four times May through September for nutrients, chlorophyll, Secchi depth (transparency), suspended solids, and algal toxins.
   - Routine Department monitoring of finished public drinking water supplies for bacteria and trace contaminants.
   - Routine bacterial monitoring for *E. coli* of swimming beaches at Missouri's state parks during the recreational season by the Department's Division of State Parks.
   - Monitoring of sediment quality by the Department at up to 20 discretionary sites annually. Sites are monitored for heavy metals (e.g., arsenic, cadmium, copper, lead, mercury, nickel, zinc) or organic contaminants (e.g., polycyclic aromatic hydrocarbons or PAHs).

2. Special Water Quality Studies

a) Objective - To characterize water quality effects from a specific pollutant source area.

b) Design Methodology - These studies are designed to verify and measure contaminants of concern based on previous water quality studies, effluent sampling, or Missouri State Operating Permit applications. These studies employ multiple sampling stations downstream and upstream (if appropriate). If contaminants of concern have significant seasonal or daily variation, the sampling design must account for such variation.

c) Number of Sites, Sampling Methods, Sampling Frequency and Parameters: The Department conducts, or contracts, upwards of 10–15 special studies annually, as funding allows. Each study has multiple sampling sites. The number of sites, sampling frequency and parameters all vary greatly depending on the study. Intensive studies would require multiple samples per site collected over a relatively short time frame.

3. Toxics Monitoring Program

The fixed station network and many of the Department's intensive studies monitor for acute and chronic toxic chemicals.[9] Major municipal and industrial dischargers must monitor for acute and chronic toxicity in their effluents as a condition of their Missouri State Operating Permit.

4. Biological Monitoring Program

a) Objectives - To develop numeric biological criteria (biocriteria) describing fish and aquatic macroinvertebrate "reference" communities in Missouri streams, to implement these criteria within state WQS, and maintain a statewide fish and aquatic macroinvertebrate monitoring program.

b) Design Methodology - Biocriteria development for fish and aquatic macroinvertebrates[10] involves identification of reference streams in each of Missouri's aquatic ecoregions and its 17 Ecological Drainage Units (EDUs), respectively. This process also includes intensive sampling of macroinvertebrate and fish communities to quantify temporal and spatial variations in reference streams within and between ecoregions, as well as to assess the aquatic communities in chemically and physically impaired streams.

c) Number of Sites, Sampling Methods, Sampling Frequency and Parameters: The Department has conducted biological sampling of aquatic macroinvertebrates for many years. Since 1991, the Department's aquatic macroinvertebrate monitoring program has consisted of standardized monitoring of approximately 45–55 sites twice annually. In addition, MDC presently has a statewide fish and aquatic macroinvertebrate monitoring program, the Resource Assessment and Monitoring (RAM) Program, designed to monitor and assess the health of Missouri's streams on a rotating basis. This program samples a minimum of 450 random and 30 reference sites every five years.

5. Fish Tissue Monitoring Program

a) Objective - To assess the ecological health of the aquatic system and/or the health of the aquatic biota (usually accomplished via whole fish samples); and to assess the potential risk to human health based on contaminant levels in fish tissue.

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[9] As defined in 10 CSR 20-7.031(1)
[10] For additional information visit: http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm

b) Design Methodology - Sites are chosen based on one of the following criteria:
- Site is believed to have water and sediment quality that represents many similarly sized streams or lakes in the region due to likeness in geology, hydrology, and land use, as well as an absence of impact from significant point or discrete nonpoint source pollution.
- Site is downstream of a significant point or discrete nonpoint source pollution area.
- Site has shown fish tissue contamination in the past.

c) Number of Sites, Sampling Methods, Sampling Frequency and Parameters:
- The Department maintains a fish tissue monitoring program to collect whole fish composite samples[11] at approximately 13 fixed sites. In previous years, this was a cooperative effort between EPA and the Department through EPA's Regional Ambient Fish Tissue (RAFT) Monitoring Program. Each site is sampled once every two years. Preferred species for sampling are common carp (*Cyprinus carpio*) or one of the redhorse sucker species (*Moxostoma* sp.). These samples are analyzed for chlorinated hydrocarbon insecticides, polychlorinated biphenyls (PCBs), lead, cadmium, mercury, and fat content.
- The Department, EPA, MDC, and DHSS also sample discretionary sites annually for fish fillet composite samples, fillets from individual fish, or fish tissue plug samples (e.g. muscle biopsy for mercury) Targeted fish species include high trophic level species such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), or sauger (*Sander canadensis*), for those contaminants that biomagnify. Benthic feeding species such as catfish species (*Siluriformes*), common carp (*Cyprinus carpio*), or sucker species (*Catostomidae*), may also be collected for contaminants that are more associated sediments. Other aquatic species and fish eggs may also be collected at select locations.

6. Volunteer Monitoring Programs

Two major volunteer monitoring programs generate water quality data in Missouri. Data generated from these programs are utilized to inform the statewide 305(b) report on general water quality health, used as a screening level tool to determine where additional monitoring is needed or to supplement other water quality data for watershed planning purposes.

- Lakes of Missouri Volunteer Program (LMVP).[12] This is a cooperative program between the Department, the University of Missouri-Columbia, and volunteers who monitor approximately 137 sites on 66 lakes across the state, including Lake Taneycomo, Table Rock Lake, and several lakes in both the St. Louis and Kansas City areas. Lake volunteers are trained to collect samples for total phosphorus, total nitrogen, chlorophyll, inorganic suspended sediments, and algal toxins. Data from this program is used by the University as part of a long-term study on the limnology of midwestern reservoirs.

[11] A composite sample is one in which several individual fish (whole fish in this case) are combined to produce one sample.
[12] For additional program information visit: http://www.lmvp.org/

- Volunteer Water Quality Monitoring Program (VWQM).[13] VWQM is an activity of the Missouri Stream Team Program, which is a cooperative project sponsored by the Department, MDC, and the Conservation Federation of Missouri (CFM). Volunteers involved in the VWQM Program monitor water quality of streams throughout Missouri. There are currently over 5,000 Stream Teams and more than 3,600 trained water quality monitors across the state.

  Training for VQWM follows a tiered structure. All volunteer monitors are required to attend an Introductory Level workshop. After completing the Introductory course, many volunteers attend at least one additional training workshop of a higher level: Levels 1, 2, or 3. Each level of training is a prerequisite for the next higher level, as is appropriate data submission. Data generated by volunteers in Levels 2, 3, and the Cooperative Stream Investigation (CSI) Program represent increasingly higher quality assurance. For CSI projects, volunteers have completed a QA/QC workshop, a field evaluation, and have been trained to collect samples following Department protocols. Upon completing Introductory, Level 1, and 2 training, volunteers will have received the basic level training needed to conduct visual stream surveys, stream discharge measurements, biological monitoring, and to collect physical and chemical measurements for pH, conductivity, dissolved oxygen, nitrate, and turbidity.

  Of those completing an Introductory course, about 35 percent proceed to Levels 1 and 2. The CSI Program uses trained volunteers to collect samples and transport them to laboratories approved by the Department. Volunteers and Department staff work together to develop a monitoring plan. All Level 2, 3, and CSI trained volunteers, are required to attend a validation session every three years to ensure equipment, reagents, and methods meet program standards.

- <u>Identification of All Existing and Readily Available Water Quality Data Sources</u>

  Data Solicitation Request

  Two calendar years prior to the current listing cycle, the Department sends out a request for all available water quality data (chemical, physical, and biological). In the solicitation, the Department requests water quality data from within a time frame of approximately two years prior to and including the current calendar year (up to October 31st of the current year). The data solicitation request is sent to multiple agencies, neighboring states, and organizations. In addition, and as part of the data solicitation process, the Department queries available water quality data from national databases such as the Water Quality Portal[14] consisting of EPA's Water Quality Exchange (WQX) data warehouse,[15] and the USGS National Water Information System (NWIS).[16]

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[13] For additional program information visit: http://dnr.mo.gov/env/wpp/VWQM.htm
[14] https://www.waterqualitydata.us/
[15] https://www.epa.gov/waterdata/water-quality-data-wqx
[16] https://waterdata.usgs.gov/nwis

The data must spatially and temporally represent the actual annual ambient conditions of the water body. Sample locations should be characteristic and representative of the main water mass or distinct hydrologic areas. With the exception of data collected for those designated uses that require seasonally based data (e.g., whole body contact recreation, biological community data, and critical season dissolved oxygen), data should be distributed over at least three seasons, over two years, and should not be biased toward specific conditions (such as runoff, season, or hydrologic conditions).

Data meeting the following criteria will be accepted:

- Samples must be collected and analyzed under a QA/QC protocol that follows EPA requirements for quality assurance project plans (QAPPs);
- Samples must be analyzed following protocols that are consistent with EPA or Standard Method procedures;
- All data submitted must be accompanied by a copy of the organization's QA/QC protocol and standard operating procedures;
- All data must be reported in standard units as recommended in the relevant approved methods;
- All data must be accompanied by precise sample location(s), preferably in either decimal degrees or Universal Transverse Mercator (UTM) coordinates;
- All data must be received in a Microsoft Excel or compatible format; and
- All data must have been collected within the requested period of record.

All readily available and acceptable data are uploaded to the Department's Water Quality Assessment (WQA) Database,[17] where the data undergoes quality control checks prior to 303(d) or 305(b) assessment processes.

- <u>Laboratory Analytical Support</u>

  The following are laboratories used for each of the various monitoring efforts conducted in Missouri:

  - Department/USGS Cooperative Fixed Station Network: USGS Lab in Denver, Colorado
  - Intensive Surveys: varies, many are completed by the Department's Environmental Services Program (ESP)
  - Effluent Toxicity Testing: many commercial laboratories
  - Biocriteria for Aquatic Macroinvertebrates: ESP and MDC
  - Fish Tissue: EPA Region VII Laboratory in Kansas City, Kansas, miscellaneous contract laboratories and MDC
  - Missouri State Operating Permit: self-monitoring or commercial laboratories

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[17] https://apps5.mo.gov/mocwis_public/wqa/waterbodySearch.do

- Department's Public Drinking Water Monitoring: ESP and commercial laboratories[18]
- Other water quality studies: many commercial laboratories

Sources of Water Quality Data

The following data sources are used by the Department to aid in the compilation of the state's integrated report (a.k.a the 305(b) report). Where quality assurance programs are deemed acceptable, additional sources would also be used to develop the state's Section 303(d) list. These sources presently include, but are not limited to:

1. Fixed station water quality and sediment data collected and analyzed by ESP personnel.
2. Fixed station water quality data collected by the USGS under contractual agreements with the Department, or organizations other than the Department.
3. Fixed station water quality, sediment quality, and aquatic biological information collected by the USGS under their National Stream Quality Accounting Network and the National Water Quality Assessment Monitoring Programs.
4. Fixed station raw water quality data collected by the Kansas City Water Services Department, the St. Louis City Water Company, the Missouri American Water Company (formerly St. Louis County Water Company), Springfield City Utilities, and Springfield's Department of Public Works.
5. Fixed station water quality data collected by the USACE. The Kansas City, St. Louis, and Little Rock Corps Districts have monitoring programs for Corps-operated reservoirs in Missouri.
6. Fixed station water quality data collected by the Arkansas Department of Environmental Quality, the Kansas Department of Health and Environment, the Iowa Department of Natural Resources, and the Illinois Environmental Protection Agency.
7. Fixed station water quality monitoring by corporations**.**
8. Annual fish tissue monitoring programs by the Department, MDC, DHSS, and EPA.
9. Special water quality surveys conducted by the Department. Most of these surveys are focused on water quality impacts of specific point source wastewater discharges. Some surveys are of well-delimited nonpoint sources, such as abandoned mining areas. Surveys often include physical habitat evaluation and monitoring of aquatic macroinvertebrates, as well as water chemistry.
10. Special water quality surveys conducted by USGS, including but not limited to:
    a) Geology, hydrology and water quality of various hazardous waste and abandoned mining area sites;
    b) Hydrology and water quality of urban nonpoint source runoff in metropolitan areas of Missouri (e.g., St. Louis, Kansas City, Springfield); and
    c) Bacterial and nutrient contamination of streams in southern Missouri.

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[18] For additional information visit: http://dnr.mo.gov/env/wpp/labs/

11. Special water quality studies by other agencies such as MDC, DHSS, and the U.S. Public Health Service.
12. Fish occurrence and distribution monitoring by MDC.
13. Fish Kill and Water Pollution Investigations Reports published by MDC.
14. Selected graduate research projects pertaining to water quality and/or aquatic biology.
15. Water quality, sediment, and aquatic biological data collected by the Department, EPA or their contractors at hazardous waste sites in Missouri.
16. Self-monitoring of receiving streams by cities, sewer districts and industries, or contractors on their behalf, for those discharges that require this kind of monitoring. This effort includes chemical and sometimes toxicity monitoring of some larger wastewater discharges, particularly those that discharge to smaller streams and have the greatest potential to affect instream water quality.
17. Compliance monitoring of receiving waters by the Department and EPA. This can include chemical and toxicity monitoring.
18. Bacterial monitoring of streams and lakes by county health departments, community lake associations, and other organizations using acceptable analytical methods.
19. Other monitoring activities done under a QAPP approved by the Department.
20. Fixed station water quality and aquatic macroinvertebrate monitoring by volunteers who have successfully completed the VWQM Program Level 2 training workshop. Data collected by volunteers who have successfully completed a Level 2 workshop is considered to be Data Code One (see Data Codes below under “Data Type, Amount, and Information Content”). Data generated from VWQM Levels 2, and 3 are considered “screening” level data and can be useful in providing an indication of water quality problems. For this reason, the data are eligible for use in distinguishing between waters in Categories 2A and 2B or Categories 3A and 3B. This data is not used to place waters in main Categories 4 and 5 because analytical procedures do not use EPA, Standard Methods, or other Department approved methods. Data from volunteers who have not yet completed a Level 2 training workshop do not have sufficient quality assurance to be used in assessment. Data generated by volunteers while participating in the Department’s CSI Program (Section II C1), or other volunteer generated data that otherwise meets the quality assurance outlined in Section II C2 of this LMD, may be used in Section 303(d) assessment.

The following data sources **cannot** be directly used to rate a water as impaired (Categories 4A, 4B, 4C or 5); however, these data sources may be used to target additional monitoring that would allow water quality assessment for Section 303(d) listing:

- Fish Management Basin Plans published by MDC.
- Fish Consumption Advisories published annually by the DHSS. Note: the Department may instead use data from data sources listed above to list individual waters as impaired due to contaminated fish tissue.

As previously stated, the Department will review all data of acceptable quality that have been

submitted to the Department prior to the first public notice of the draft 303(d) list. However, the Department will reserve the right to review and use data of acceptable quality submitted after this date if the new data results in a change to the assessment outcome of a water body.

Data Quality Considerations

- DNR Quality Assurance/Quality Control Program

  The Department and EPA Region VII have completed a Quality Management Plan. All environmental data generated directly by the Department, or through contracts funded by the Department, or EPA require a QAPP.[19] The agency or organization responsible for collecting and/or analyzing environmental data must write and adhere to a QAPP approved through the Department's Quality Management Plan. Any environmental data generated via a monitoring plan with a Department approved QAPP are considered suitable for use in water quality assessment and the 303(d) listing. This includes data generated by volunteers participating in the Department's CSI Program. Under this program, the Department's ESP will audit select laboratories. Laboratories that pass this audit will be approved for the CSI Program. Individual volunteers who collect field samples and deliver them to an approved laboratory must first successfully complete Department training on how to properly collect and handle environmental samples. The types of information that allow the Department to make a judgment on the acceptability of a quality assurance program are: (1) a description of the training and work experience of the persons involved in the program, (2) a description of the field meters as well as maintenance and calibration procedures, (3) a description of sample collection as well as handling procedures, and (4) a description of all laboratory analytical methods.

- Other Quality Assurance/Quality Control Programs

  Data generated in the absence of a Department-approved QAPP may be used to assess a water body if the Department determines that the data are adequate after reviewing and accepting the quality assurance procedures plan used by the data generator. This review would include: (1) names of all persons involved in the monitoring program, their duties, and a description of their training and work related experience, (2) all written procedures, Standard Operating Procedures, or QAPPs pertaining to the monitoring effort, (3) a description of all field methods used, brand names and model numbers of any equipment, as well as a description of calibration and maintenance procedures, and (4) a description of laboratory analytical methods. This review may also include an audit by the Department's ESP.

- Data Qualifiers

  The Department will handle data qualifiers in different ways depending upon the qualifier, the analytical detection limit, and the numeric WQS:

[19] For additional information visit: http://www.epa.gov/quality/qapps.html

- *Less Than Qualifier "<"* - The Department will use half the reported less than value, unless circumstances cause issues with assessment. Examples of this include but are not limited to:
  - Less than values for bacteria. Since the Department calculates a geometric mean, any value less than 1.0 could cause the data to be skewed when using the method of multiplying the values then dividing by the n^{th} root.
  - Less than values below the criterion but still close to the criterion or less than values that are above the criterion. In these cases, the Department will not use the data for assessments.
- *Non-detection Qualifier "ND"* - The Department treats these the same as the less than qualifier, except for when a value is not reported. For these cases, the Department will use the method detection limit as the reported less than value.
- *Greater Than Qualifier ">"* - The Department will only consider data with this qualifier for assessments when pertaining to bacteria. In the cases of bacterial data, the reported greater than value is doubled before being used in the assessment calculation. In circumstances where this practice is the sole reason for impairment, the greater than value(s) will be used as the reported value(s) in the assessment calculation (i.e., not doubled).
- *Estimated Values "E"* - These values, reported as an estimate, are usually characterized as being above the laboratory quantification limit but below the laboratory reporting limit. High bacteria values are sometimes reported as estimates due to the analytical method used. This usually means the sample had to be diluted during analysis because the true bacteria count was higher than the method reporting maximum. The Department will not use estimated values if the value reported is near the criterion. If the value is well above or well below the criterion, then it will be used in assessments.

- Data Age

  More recent data are preferable for assessing present conditions; however, older data may also be used if the data remains reflective of present conditions.

  - If the Department uses data older than **seven years** to make a Section 303(d) list decision, a written justification for the use of such data will be provided.
  - If a water body has not been listed previously and all data indicating an impairment is older than seven years, then the water body shall be placed into Category 2B or 3B and prioritized for future sampling.
  - A second consideration is the age of the data relative to significant events that may affect water quality. For example, data collected prior to the initiation, closure, or significant change in a wastewater discharge, or prior to a large spill event or the reclamation of a mining or hazardous waste site, may not be representative of present conditions. Even if the data were less than seven years old, such "pre-event" data would not be used to assess present conditions. It could, however, be used to show

trends or determine changes in water quality before and after an event.

- Data Type, Amount, and Information Content

  EPA recommends establishing a series of data codes that rate data quality by the kind and quantity of data present at a particular location (EPA 1997[20]). The codes are single-digit numbers from one to four, indicating the relative degree of assurance held in a particular environmental dataset. Data Code One indicates the least assurance or the least number of samples or analytes and Data Code Four indicates the greatest. Based on EPA's guidance, the Department uses the following rules to assign code numbers to data:

  - Data Code[21] One: All data not meeting the requirements of the other data codes.
  - Data Code Two:
    - Chemical data collected quarterly to bimonthly for at least three years; or
    - Intensive studies that monitor several nearby sites repeatedly over short periods of time; or
    - At least three composite or plug fish tissue samples per water body; or
    - At least five bacterial samples collected during the recreational season of one calendar year.
  - Data Code Three:
    - Chemical data collected at least monthly for more than three years on a variety of water quality constituents including heavy metals and pesticides; or
    - A minimum of one quantitative biological monitoring study of at least one aquatic assemblage (fish, macroinvertebrates, or algae) at multiple sites, multiple seasons (spring and fall), or multiple samples at a single site when data from that site is supported by biological monitoring at an appropriate control site.
  - Data Code Four:
    - Chemical data collected at least monthly for more than three years that provides data on a variety of water quality constituents including heavy metals and pesticides, and chemical sampling of sediment and fish tissue; or
    - A minimum of one quantitative biological monitoring study of at least two aquatic assemblages (fish, macroinvertebrates, or algae) at multiple sites.

  In Missouri, the primary purpose of Code One data is to provide a rapid and inexpensive method of screening large numbers of water bodies for obvious water quality problems and to determine where more intensive monitoring is needed. In preparation of the state's Integrated Report, data from all four data quality levels are used. Most data are of Data

[20] *Guidelines for the Preparation of the Comprehensive State Water Quality Assessments (305b) and Electronic Updates*, 1997. (http://water.epa.gov/type/watersheds/monitoring/repguid.cfm)
[21] Data Code One is equivalent to data water quality assurance Level One in 10 CSR 20-7.050 General Methodology for Development of Impaired Waters List, subsection (2)(C), Data Code Two is equivalent to Level 2, etc.

Code One quality, and without Code One data, the Department would not be able to assess a majority of the state's waters.

In general, when selecting water bodies for the Missouri 303(d) list, only Code Two data (or higher) are used, unless the Department can accurately and confidently characterize the problem using Code One data.[22] Code Two data provides a higher level of assurance that a WQS is not being attained and that a TMDL study is necessary. All water bodies placed in Categories 2 or 3 receive high priority for additional monitoring so that data quality is upgraded to at least Data Code Two. Category 2B and 3B waters will be given higher priority than Categories 2A and 3A.

EPA suggests that states use these codes as a way of describing the type of information collected, the frequency of data collection, the spatial/temporal coverage, and the data quality. Missouri has followed this guidance in using the data codes to explain the information type, collection frequency, and spatial/temporal coverage; however, its application differs in regard to data quality. For data quality, the Department reviews the data, as well as the collection methods and laboratory analyses used to generate the data, on a project-specific basis. If the data is of acceptable quality, the Department marks the project and all associated data as QA acceptable. The Department only uses QA acceptable data for assessments, unless the data provides additional corroboration of impairment or attainment status.

- Data Collection Considerations - Dissolved Oxygen and Flow

In streams, dissolved oxygen is highly dependent on flow. For stream assessments, dissolved oxygen measurements must be accompanied by same-day flow measurements. Dissolved oxygen must also be measured from the flowing portion of the stream and not be influenced by flooding or backwater conditions.

How Water Quality Data is Evaluated to Determine Impairment Status for 303(d) Listing Purposes

I. Physical, Chemical, Biological and Toxicity Data

During each reporting cycle, the Department and stakeholders review and revise the guidelines for determining water quality impairment. The guidelines, shown in Appendix B & C, provide general rules of data use and assessment. Additionally, Appendix D provides details about specific statistical analyses used in impairment determinations. If trend analysis indicates that presently unimpaired waters will become impaired prior to the next listing cycle, these "threatened waters" will be judged as impaired. Where Missouri's WQS antidegradation provisions apply, those provisions shall be upheld. Numeric criteria have

[22] When a listing amendment or delisting of a 303(d) water is made using only Code One data, a document will be prepared that includes a display of all data and a presentation of all statistical tests or other evaluative techniques that document the scientific defensibility of the data. This requirement applies to all Code One data identified in Appendix B of this document.

been adopted into state WQS and are used, as described in Appendix B, to make use attainment decisions.

II. Weight of Evidence Approach

When evaluating narrative criteria described in state WQS, the Department will use a weight of evidence analysis for assessing numerical translators not yet adopted into state WQS (see Appendix C). Under the weight of evidence approach, all available information is examined and the greatest weight is given to data providing the "best supporting evidence" for an attainment decision. Determination of "best supporting evidence" will be made using best professional judgment by Department staff that consider factors such as data quality and site-specific environmental conditions. For those analytes with numeric thresholds, the threshold values given in Appendix C will trigger a weight of evidence analysis to determine the existence or likelihood of a use impairment and the appropriateness of proposing a 303(d) listing based on narrative criteria. This weight of evidence analysis will include the use of other types of environmental data when it is available, or collection of additional data to make the most informed use attainment decision. Examples of other relevant environmental data might include physical or chemical data, biological data on fish or aquatic macroinvertebrates (i.e., Fish Index of Biotic Integrity (fIBI) and Macroinvertebrate Stream Condition Index (MSCI), respectively), fish tissue data, and water or sediment toxicity data.

Biological data will be given greater weight in a weight of evidence analysis for making attainment decisions for aquatic life use and subsequent Section 303(d) listings. Whether or not numeric translators of biocriteria are met is a strong indicator for the attainment of aquatic life use. Moreover, the Department retains a high degree of confidence in an attainment decision based on biological data that is representative of water quality conditions.

When the weight of evidence analysis suggests but does not provide strong scientifically valid evidence of impairment, the Department will place the water body in question in Categories 2B or 3B. The Department will produce a document showing all relevant data and the rationale for the attainment decision. All such documents will be available to the public at the time of the first public notice for the proposed 303(d) list. Only after full consideration of all comments on the proposed list will a final recommendation be made on the listing of a water body based on narrative criteria.

III. Biological Data

Methods for assessing biological data typically receive considerable attention during the public comment period of development of the LMD. Currently, a defined set of biocriteria[23] are used to evaluate biological data for assessing compliance with WQS. These

[23] This refers to Missouri's Water Quality Standards (10 CSR 20-7.031) Section 5 (Specific Criteria) (R) (Biocriteria). Although the Department uses the term "criteria" in association with biological metrics and indices throughout this document, numeric

biocriteria contain numeric thresholds, that when exceeded relative to prescribed assessment methods, serve as a basis for identifying candidate waters for Section 303(d) listing. Biocriteria are based on three types of biological data: (1) aquatic macroinvertebrate community data; (2) fish community data; and, (3) a catch-all class referred to as "other biological data."

In general, when interpreting macroinvertebrate data where Stream Habitat Assessment Project Procedure (SHAPP; MoDNR 2016b) scores indicate habitat is less than 75 percent of either reference or appropriate control stream scores and other data indicating impairment by a discrete pollutant is absent, a water body judged to be impaired will be placed in Category 4C. When interpreting fish community data, a provisional multi-metric habitat index called the QCPH1 index is used to identify stream habitat in poor condition. The QCPH1 index separates adequate habitat from poor habitat using a 0.39 threshold value; whereby, QCPH1 scores greater than 0.39 indicate available stream habitat is adequate, and scores less than 0.39 indicate stream habitat is poor. In the absence of other data indicating impairment by a discrete pollutant, impaired fish communities with poor habitat will be placed in Category 4C. Additional information about QCPH1 is provided in the *Considerations for the Influence of Habitat Quality and Sample Representativeness* section.

The sections below describe methods used to evaluate the three types of biological data (macroinvertebrate community, fish community, and other biological data). Background information is included on the development and scoring of biocriteria, procedures for assessing biological data, methods used to ensure sample representativeness, and additional information used to aid in assessing biological data, such as the weight of evidence approach.

Aquatic Macroinvertebrate Community Data

The Department conducts aquatic macroinvertebrate assessments to determine macroinvertebrate community health as a function of habitat and water quality. The health of a macroinvertebrate community is directly related to habitat and water quality. Almost all macroinvertebrate evaluations compare the health of the "target" community to the health of macroinvertebrate communities from reference streams of the same general size and usually the same EDU.

The Department's approach to monitoring and evaluating aquatic macroinvertebrates is largely based on *Biological Criteria for Wadeable/Perennial Streams of Missouri* (MoDNR 2002). This document provides the framework for numeric biocriteria relevant to the protection of aquatic life use for wadeable streams in the state. Biocriteria were developed using wadeable reference streams that occur in specific EDUs, as mapped by the Missouri Resource Assessment Partnership (MORAP; reference Figure 1). For macroinvertebrates, the numeric biocriteria translator is expressed as a multiple metric index referred to as the

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biological criteria have not been promulgated in the rule. This document uses the developed numerical biological metrics and indices as translators for the Biocriteria portion of 10 CSR 20-7.031(5)(R) [3/31/2018].

MSCI. The MSCI includes four metrics: Taxa Richness (TR); Ephemeroptera, Plecoptera, and Trichoptera Taxa (EPTT); Biotic Index (BI); and the Shannon Diversity Index (SDI). These metrics are considered indicators of stream health that change predictably in response to the environmental condition of a stream.

Metric values are determined directly from macroinvertebrate sampling. To calculate the MSCI, each metric is normalized to unitless values of five, three, or one, which are then added together for a total possible score of 20. MSCI scores are divided into three levels of stream condition:

- Fully Biologically Supporting (16–20),
- Partially Biologically Supporting (10–14), and
- Non-Biologically Supporting (4–8).

Partially and Non-Biologically Supporting streams may be considered impaired and are candidates for Section 303(d) listing.

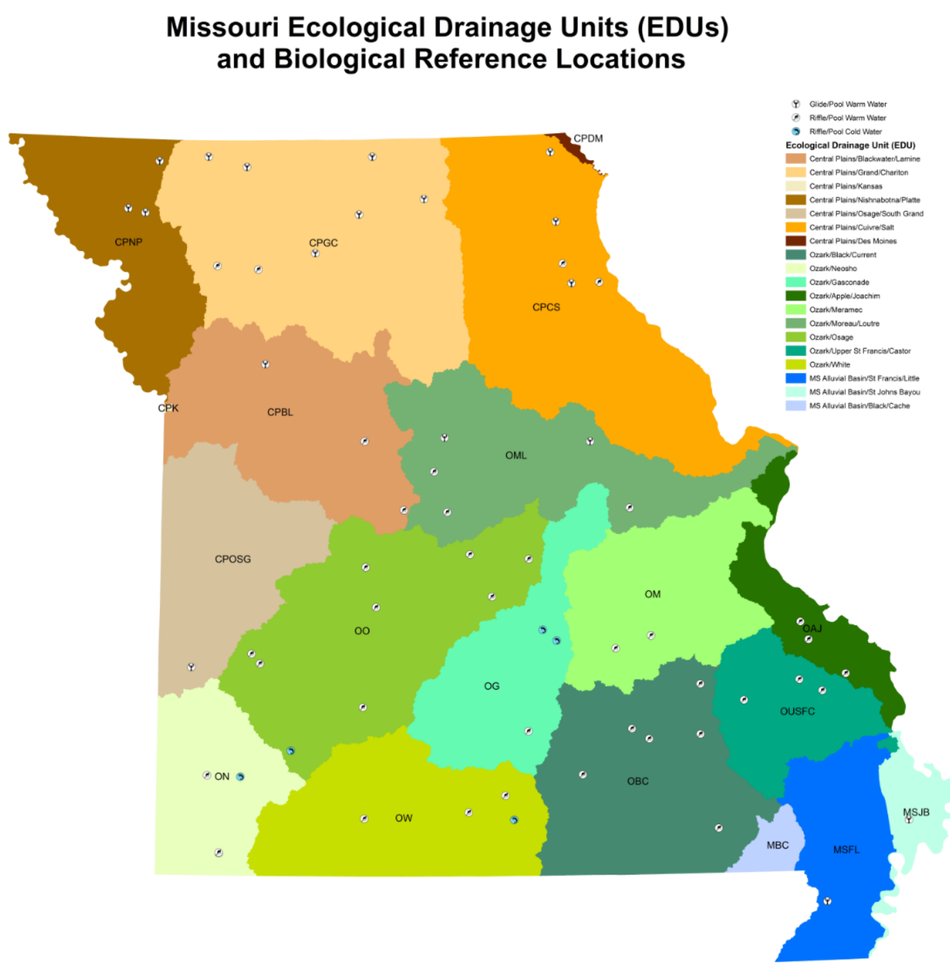

Figure 3: Missouri Ecological Drainage Units (EDUs) and Biological Reference Locations

The unitless metric values (five, three, or one) were developed from the lower quartile of each metric's distribution, as calculated from reference streams for each EDU. The lower quartile (25th percentile) of each metric equates to the minimum value still representing unimpaired conditions. In operational assessments, metric values below the lower quartile of reference conditions are typically judged as impaired (US EPA 1996, Ohio EPA 1990, Barbour *et al.* 1996). Using the 25th percentile of reference conditions as a standard for impairment for each metric allows the Department to filter out natural variability.

For metrics with values that decrease with increasing impairment (TR, EPTT, SDI), any value above the lower quartile of the reference distribution receives a score of five. For the BI, whose value increases with increasing impairment, any value below the upper quartile (75th percentile) of the reference distribution receives a score of five. The remainder of each metric's potential quartile range below the lower quartile is bisected and scored either a three or a one. If the metric value is less than or equal to the quartile value and greater than the bisection value, it is scored a three. If the metric value is less than or equal to the bisection value, it is scored a one.

MSCI scores meeting data quality considerations may be assessed for the protection of aquatic life using the following procedures:

Determining Full Attainment of Aquatic Life Use:

- For seven or fewer samples, 75 percent of the MSCI scores must be 16 or greater. Fauna achieving these scores are considered to be very similar to biocriteria reference streams.
- For eight or more samples, results must be statistically similar to representative reference or control streams.

Determining Non-Attainment of Aquatic Life Use:

- For seven or fewer samples, 75 percent of the MSCI scores must be 14 or lower. Fauna achieving these scores are considered to be substantially different from biocriteria reference streams**.**
- For eight or more samples, results must be statistically dissimilar to representative reference or control streams.

Data will be judged inconclusive when outcomes do not meet requirements for decisions of full or non-attainment.

As noted, when eight or more samples are available, results must be statistically similar or dissimilar to reference or control conditions in order to make an attainment decision. To accomplish this, a binomial probability with an appropriate level of significance (α=alpha), is calculated based on the null hypothesis that the test stream would have a similar percentage of MSCI scores that are 16 or greater as reference streams. The significance level is set at $\alpha=0.1$, meaning if the p-value of the hypothesis test is less than α, the hypothesis is considered statistically significant. The significance level of α is in fact the probability of making a wrong

decision and committing a Type I error (rejecting a true null hypothesis). When the Type I error rate is less than α=0.1, the null hypothesis is rejected. Inversely, when the Type I error rate is greater than α=0.1, the null hypothesis is accepted.

For comparing samples from a test stream to samples collected from reference streams in the same EDU, the percentage of samples from reference streams scoring 16 or greater is used to determine the probability of "success" and "failure" in the binomial probability equation. For example, if 84 percent of the reference stream MSCI scores in a particular EDU are 16 or greater, then 0.84 would be used as the probability of success and 0.16 would be used as the probability of failure. Note that Appendix D states to rate a stream as impaired if the frequency of biocriteria reference streams with fully supporting biological scores is greater than five percent more than the test stream, thus, a value of 0.79 (0.84 - 0.05) would actually be used as the probability of success in the binomial distribution equation.

Binomial Probability Example:

Reference streams from the Ozark/Gasconade EDU classified as riffle/pool stream types with warm water temperature regimes produce fully biologically supporting streams 85.7 percent of the time. In the test stream of interest, six out of ten samples resulted in MSCI scores of 16 or more. Calculate the Type I error rate for the probability of getting six or fewer fully biologically supporting scores in ten samples.

The binomial probability formula may be summarized as:

$$p^n + (n!/\ X!(n-X)!*p^n q^{n-x}) = 1$$

where,
Sample Size (n) = 10
Number of Successes (X) = 6
Probability of Success (p) = 0.857 - 0.05 = 0.807
Probability of Failure (q) = 0.193

Excel has the BINOM.DIST function that will perform this calculation:

=BINOM.DIST(number_s,trials,probability_s,cumulative)
=BINOM.DIST(6,10,0.807,TRUE)

Using Excel's Binomial Function	
Probability of Success	0.807
Sample Size	10
# of Successes	6
Type 1 Error Rate	0.109

Since 0.109 is greater than the test significance level (minimum allowable Type I error rate) of $\alpha = 0.1$, we accept the null hypothesis that the test stream has the same percent of fully biologically supporting scores as the same type of reference streams from the Ozark/Gasconade EDU. Thus, this test stream would be judged as unimpaired.

If under the same scenario, there were only 5 samples from the test stream with MSCI scores of 16 or greater, the Type I error rate would change to 0.028, and since this value is less than the significance level of $\alpha=0.1$, the stream would be judged as impaired.

Within each EDU, MSCI scores are categorized by sampling regime (glide/pool vs. riffle/pool) and temperature regime (warm water vs. cold water). The percentage of fully biologically supporting scores for the Mississippi River Alluvial Basin/Black/Cache EDU is not available due to the lack of reference sites in this region. Percentages of fully biologically supporting samples per EDU is not included here but can be made available upon request. The percentage of reference streams per EDU that are fully biologically supporting may change periodically as additional macroinvertebrate samples are collected and processed from reference samples within an EDU.

Sample Representativeness

Field and laboratory methods used by the Department to collect and process macroinvertebrate samples are contained in the document *Semi-Quantitative Macroinvertebrate Stream Bioassessment* (MoDNR 2015). Macroinvertebrates are identified to levels following standard operating procedures contained in *Taxonomic Levels for Macroinvertebrate Identifications* (MoDNR 2016b). Macroinvertebrate monitoring is accompanied by physical habitat evaluations, as described in the document *Stream Habitat Assessment* (MoDNR 2016a). For the assessment of macroinvertebrate samples, available information must meet Data Code Levels 3 and 4, as described in Section II.C of this LMD. Data coded as Levels 3 and 4 represent environmental data providing the greatest degree of assurance. Thus, at a minimum, macroinvertebrate assessments include multiple samples from a single site, or samples from multiple sites within a single reach.

It is important to avoid situations where poor or inadequate habitat prohibits macroinvertebrate communities from being assessed as fully biologically supporting. Therefore, when assessing macroinvertebrate samples, the quality of available habitat must be similar to that of reference streams within the same EDU. The Department's policy for addressing this concern has been to exclude MSCI scores from an assessment when accompanying habitat scores are less than 75 percent of the mean habitat scores from reference streams of a given EDU. The following procedures outline the Department's method for assessing macroinvertebrate communities from sites with poor or inadequate habitat.

Assessing Macroinvertebrate Communities from Poor or Inadequate Habitat:

- If less than half the macroinvertebrate samples in an assessed stream segment have habitat scores less than 75 percent of the mean score for reference streams in that EDU, any sample that scores less than 16 and has a habitat score less than 75 percent of the mean reference stream score for that EDU, is excluded from the assessment process.
- If at least half the macroinvertebrate samples in an assessed stream segment have habitat scores less than 75 percent of the mean score for reference streams in that EDU and the assessment results in a judgment that the macroinvertebrate community is impaired, the assessed segment will be placed in Category 4C impairment due to poor aquatic habitat.
- If one portion of the assessment reach contains two or more samples with habitat scores less than 75 percent of reference streams from that EDU while the remaining portion does not, the portion of the stream with poor habitat scores could be separately assessed as a Category 4C stream, permitting low MSCI scores.

Macroinvertebrate sampling methods vary by stream type. One method is used in riffle/pool predominant streams, and the other method is for glide/pool predominant streams. For each stream type, macroinvertebrate sampling targets three habitats.

- For riffle/pool streams, the three habitats sampled are flowing water over coarse substrate, non-flowing water over depositional substrate, and rootmat substrate.
- For glide/pool streams, the three habitats sampled are non-flowing water over depositional substrate, large woody debris substrate, and rootmat substrate.

In some instances, one or more of the habitats sampled can be limited or missing from a stream reach, which may affect MSCI scores. Macroinvertebrate samples based on only two habitats may have an MSCI score equal to or greater than 16, but it is also possible that a missing habitat may lead to a decreased MSCI score. Although MoDNR stream habitat assessment procedures take into account a number of physical habitat parameters from the sample reach (e.g., riparian vegetation width, channel alteration, bank stability, bank vegetation protection), they do not exclusively measure the quality or quantity of the three predominant habitats from each stream. When evaluating potentially impaired macroinvertebrate communities, the number of habitats sampled, in addition to the stream habitat assessment score, will be considered to ensure MSCI scores less than 16 are properly attributed to poor water quality or poor or inadequate habitat condition.

Biologists responsible for conducting biological assessments will determine the extent to which habitat availability is responsible for a non-supporting (<16) MSCI score. If it is apparent that a non-supporting MSCI score was due to limited habitat, these effects will be stated in the biological assessment report. This limitation will then be considered when deciding which Listing Methodology Category is most appropriate for an individual stream. This procedure, as part of the Department's biological assessment, will aid in

determining whether impaired macroinvertebrate samples have MSCI scores based on poor water quality conditions or habitat limitations.

To ensure assessments are based on representative macroinvertebrate samples, samples collected during or shortly after prolonged drought, shortly after major flood events, or any other conditions that fall outside the range of environmental conditions under which reference streams in the EDU were sampled, will not be used to make an attainment decision for a Section 303(d) listing or any other water quality assessment purposes. Sample “representativeness” is judged by Water Protection Program (WPP) staff after reading the biomonitoring report for that stream, and if needed, consulting with biologists from the Department’s ESP. Regarding smaller deviations from “normal” conditions, roughly 20 percent of reference samples failing to meet a fully biologically supporting MSCI score were collected following weather or climatic extremes; as a result, biocriteria for a given EDU are inclusive of samples collected during not only ideal macroinvertebrate rearing conditions, but also during the weather extremes that Missouri experiences.

Assessing Small Streams

Occasionally, macroinvertebrate monitoring is needed to assess streams smaller than the typical wadeable/perennial reference streams listed in Table I of Missouri’s WQS. Smaller streams may include Class C streams (streams that may cease flow in dry periods but maintain permanent pools which support aquatic life) or those that are unclassified. Assessing small streams involves comparing test stream and candidate reference stream MSCI scores first to Wadeable/Perennial Reference Stream (WPRS) criteria, and then second to each other.

In MoDNR’s Biological Criteria Database, there are 16 candidate reference streams labeled as Class P, 23 labeled as Class C, and 24 labeled as Class U. In previous work by MoDNR, when the MSCI was calculated according to WPRS criteria, the failure rate for candidate reference streams was 31 percent for Class P, 39 percent for Class C, and 70 percent for Class U. The data trend showed a higher failure rate for increasingly smaller high-quality streams when scored using WPRS biological criteria. This trend demonstrates the need to include the utilization of candidate reference streams in biological stream assessments.

Prior to the 2014 revision of the Missouri WQS there was no size classification for streams. The 2014 revision codified size classification for rivers and streams based on five size categories for Warm Water, Cool Water, and Cold Water Habitats. The size classifications are defined as Headwater, Creek, Small River, Large River and Great River. Water permanence continues to be classified as Class P (streams that maintain permanent flow even in drought periods); Class C (streams that cease flow in dry periods but maintain permanent pools which support aquatic life); and the newly adopted Class E (streams that do not maintain permanent surface flow or permanent pools, but have surface flow or pools in response to precipitation events).

Table I of Missouri's WQS lists 62 wadeable/perennial reference streams that provide the current basis for numeric biocriteria. Wadeable/perennial reference streams are a composite of Creek and Small River size classes. Interpretation of Creek (Size Code 2) and Small River (Size Code 3) is based on the MORAP Shreve Link number found in Table 2. These wadeable/perennial reference streams were selected prior to the 2014 revision of the Missouri WQS and were based on the former Table H (Stream Classifications and Use Designations). All, or a portion, of seven wadeable/perennial reference streams are Class C; and all, or a portion, of 57 wadeable/perennial reference streams are Class P.

As part of the 2014 revision of the Missouri WQS, classified streams were changed from only waters listed in Table H to include a modified version of the 1:100,000 National Hydrography Dataset (NHD). This dataset provides a geospatial framework for classified streams and is referred to as the Missouri Use Designation Dataset (MUDD). The streams and rivers now listed in MUDD contain approximately 100,000 miles of newly classified streams, many of which are the Headwater size class. Interpretation of Headwater size (Size Code 1) is based on the MORAP Shreve Link number found in Table 2.

Table 2. Missouri Resource Assessment Partnership Shreve Link Number for Stream Size Code

Stream Size	Size Code	Plains Shreve Link Number	Ozark Shreve Link Number
Headwater	1	1-2	1-4
Creek	2	3-30	5-50
Small River	3	31-700	51-450
Large River	4	701-maximum	451- maximum
Great River	5	Missouri & Mississippi	Missouri & Mississippi
Unknown	0		

In natural channels, biological assessments will be based on criteria established from streams of comparable size and permanence. Current WPRS criteria and the MDC fIBI metrics only apply to Creek and Small River size categories. MDC fIBI metrics apply exclusively to the Ozarks ecoregion. Biocriteria have not been established for the size categories of Great River, Large River, or Headwater. The need for alternate criteria for Headwater-size class streams is supported by the higher failure rate (70 percent) for small-size streams when scored using wadeable/perennial reference stream biocriteria (MoDNR, unpublished data). Because headwater-stream biocriteria have not been established, the utilization of candidate headwater reference streams and draft criteria will be necessary to perform biological stream assessments of headwater-size streams until scientifically defensible criteria have been developed (Figure 2).

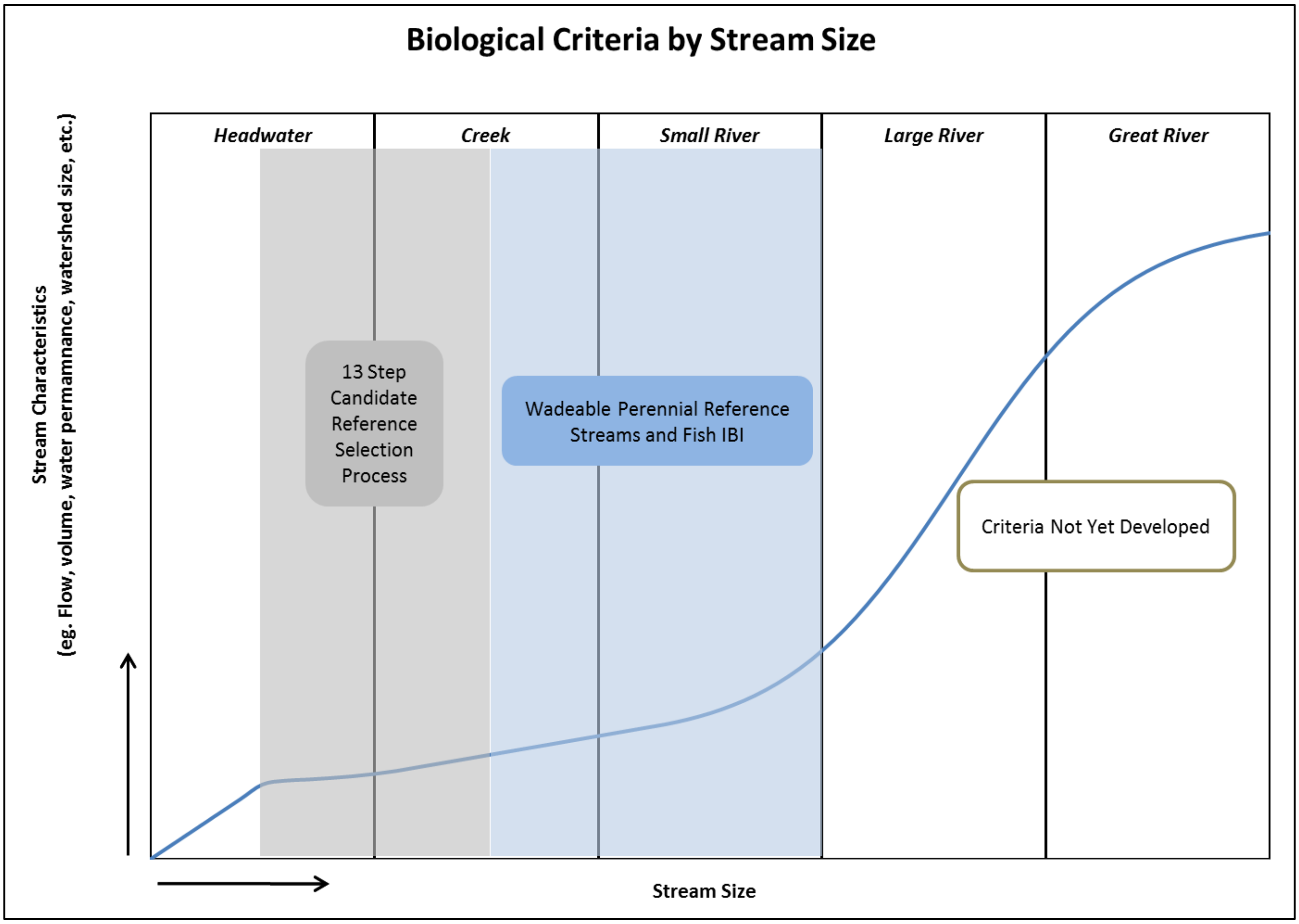

Figure 2. Biological criteria based on stream size classification.

For test streams that are smaller than wadeable perennial reference streams, the Department samples five candidate reference streams of same or similar size and Valley Segment Type (VST) in the same EDU twice during the same year the test stream is sampled (additional information about selecting small control streams is provided below). Although in most cases the Department samples small candidate reference streams concurrently with test streams, existing data may be used if a robust candidate reference stream dataset exists for the EDU.

If the ten small candidate reference stream scores are similar to wadeable perennial reference stream criteria, then they and the test stream are considered to have a Class C or Class P warm water habitat designated use, and the MSCI scoring system in the LMD should be used. If the small candidate reference streams have scores lower than the wadeable perennial reference streams, the assumption is that the small candidate reference streams, and the test stream, represent designated uses related to stream size that are not yet approved by EPA in the state’s WQS. The current assessment method for test streams that are smaller than reference streams is stated below.

- If 75 percent of the ten candidate reference stream scores are 16 or greater when compared to WPRS criteria, then the test stream will be assessed using MSCI based procedures in the LMD.

- If 75 percent of the ten candidate reference stream scores are below 16 when compared to WPRS criteria then:

  a) The test stream will be judged "unimpaired" if test stream scores meet criteria developed from the candidate reference stream scores. If 75 percent of the test stream scores are 16 or greater when compared to criteria developed from the candidate reference streams, the stream will be judged "unimpaired."
  b) The test stream will be assessed as having an "impaired" macroinvertebrate community if test stream scores do not meet criteria developed from the candidate reference stream scores. If 75 percent of the test stream scores are below 16 when compared to criteria developed from the candidate reference streams, the stream will be judged "impaired."
  c) The test stream will be judged "inconclusive" if the requirements in a) and b) are not met.

All work will be documented on the macroinvertebrate assessment worksheet and be made available during the public notice period.

Selecting Small Candidate Reference Streams

Accurately assessing streams that are smaller than reference streams begins with properly selecting small candidate reference streams. Candidate reference streams are smaller than WPRS streams and have been identified as "best available" reference stream segments in the same EDU as the test stream according to watershed, riparian, and in-channel conditions. The selection of candidate reference streams is consistent with framework provided by Hughes *et al.* (1986) with added requirements that candidate reference streams must be from the same EDU and have the same or similar values for VST parameters. If candidate reference streams perform well when compared to WPRS, then test streams of similar size and VST are expected to do so as well. VST parameters important for selection are based on temperature, stream size, flow, geology, and relative gradient, with emphasis placed on the first three parameters.

The stepwise process for candidate reference stream selection is listed below. The Department will fully document its decision-making rationale regarding the steps in this process which will be available upon request and will include but are not limited to: GIS layers used, segment IDs eliminated at the various steps, candidate stream list for field verification, etc.

1. Determine test stream reaches to be assessed. *Missouri Department of Natural Resources staff in the Water Protection Program's Monitoring and Assessment Unit will use data that indicates potential impairment to determine where additional studies are*

needed. Department staff with the Environmental Services Program's Aquatic Bioassessment Unit will be used to conduct studies requested by the WPP.

2. Identify appropriate EDU. *The Ecological Drainage Unit in which the test stream is located will be identified so that applicable biological criteria can be used to score macroinvertebrate data collected by Department biologists.*

3. Determine five variable VST of test stream segments (1st digit = temperature; 2nd digit = size; 3rd digit = flow; 4th digit = geology; and 5th digit = relative gradient). *This five-digit VST code provides a description of the test stream for later use in selecting appropriate candidate reference streams that are similar to the test stream (giving temperature, size, and flow the highest importance).*

4. Filter all stream segments within the same EDU for the relevant five variable VSTs (1st and 2nd digits especially critical for small streams). *The five VST features of the test stream will be determined by checking the "AQUATIC.STRM_SEGMENTS" layer in GIS software (e.g., ArcMap). This layer has an associated Attribute Table that has, among many other features, the five-digit VST code for classified Missouri streams. During the filtering process, the five-digit code (listed as "VST_5VAR" in the Attribute Table) of the test stream is chosen in an ArcMap tool called "Select by Attributes." The five-digit code of the test stream is entered into this ArcMap tool, which can then be used to list only streams with the same five VST variables while excluding (i.e., "filtering out") all other streams with different variables.*

5. Filter all potential VST stream segments for stressors against available GIS layers (e.g., point sources, landfills, CAFOs, lakes, reservoirs, mining, etc.). *A GIS layer that includes the stream segments selected in Step 4 will be created. The proximity of these selected stream layers will be evaluated relative to stressor layers cataloged in GIS using filtering steps similar to those described above. Stream segments with stressors having documented impacts will be eliminated from further consideration. The presence of a single potential stressor will not automatically lead to a stream reach being rejected; rather, the aggregate of potential stressors in a watershed will be evaluated.*

6. Filter all potential VST stream segments against historical reports and databases. *Past accounts of occurrences that may result in a stream failing to meet the "best available, least impaired" criteria will be evaluated. These incidents may include events such as fish kills, combined sewer overflows, or past environmental emergencies (e.g., releases of toxic substances). Exceptions can be made when the cause of the incident no longer exists and there are no lingering effects. In contrast, historical reports may also include studies by other biologists that support the use of a stream segment as a candidate reference stream.*

7. Calculate land use categories of candidate reference streams (e.g., percentage of forest, grassland, impervious surface, etc.) in GIS mapping software using available land cover

datasets (Sources of land use data that are currently used are NLCD 2011 and MoRAP 2005). Candidate reference streams with the same or similar AES type as the test stream (within the EDU) will be given preference throughout the selection process. In addition, candidate reference streams should also be chosen from candidate reference stream watersheds whose land use composition is representative of test stream's AES, and generally representative of EDU land uses. Candidate reference stream watersheds will be excluded if impervious area covers greater than 10 percent of the watershed area *(Center for Watershed Protection, 2003).*

8. Develop candidate stream list with coordinates for field verification.

9. Field verify candidate list for actual use (e.g., animal grazing, in-stream habitat, riparian habitat), migration barriers (e.g., culverts, low water bridge crossings) representativeness, (gravel mining, and other obvious human stressors). *Biologists can make additional fine-scale adjustments to the list of candidate streams by visiting sites in person. Certain features visible on-site may have been missed with GIS and other computer based filtering. Stream flow must be field verified to be similar to test streams.*

10. *Of the sites remaining after field verification and elimination, at least five of the top ranked candidate sites will be subjected to additional evaluation outlined below.*

> *For steps 4-9: These steps occur at the EDU level identified in step 2. These steps look at all streams within the identified EDU including those in the same Aquatic Ecological System (AES) Type as the test stream. Streams in the same AES Type as the test stream (within the identified EDU) will be given preference and be selected to go through the remaining steps (10-13) below.*

11. Collect chemical, biological, habitat, and possibly sediment field data. *Collection of physical samples is the ultimate manner in which the quality of a stream is judged. Although factors evaluated in the previous steps are good indicators of whether a stream is of reference quality, it is the evaluation of chemical, physical and biological attributes in relation to other candidate reference streams that is the final determinant. If chemical sampling documents an exceedance of water quality standards, the candidate reference stream will be eliminated from consideration.*

12. After multiple sampling events evaluate recent field data against available historical chemical, physical, biological, and land use data from each corresponding candidate reference stream. *Aquatic systems are subject to fluctuation due to weather, stream flow, and other climatic conditions. Land use in the watershed of a candidate reference also can change over time. It is therefore important to compare recent data to available historical data to evaluate if watershed conditions have changed over time. If this evaluation indicates that the candidate reference stream conditions are similar to or have*

improved relative to historical conditions, they will be retained. If historical data are not available to make the comparisons, the candidate reference streams will be retained.

13. If field data are satisfactory, retain candidate reference stream label in database. *Reference streams and candidate reference streams are labeled as such in a database maintained by the Department's Aquatic Bioassessment Unit in Jefferson City, Missouri.*

Fish Community Data

The Department utilizes fish community data to determine if aquatic life use is supported in certain types of Missouri streams. When properly evaluated, fish communities serve as important indicators of stream health. In Missouri, fish communities are surveyed by MDC. Each year, MDC selects an aquatic subregion from which randomly selected 2nd to 5th order sized streams are surveyed. Fish sampling follows procedures described in the document *Resource Assessment and Monitoring Program: Standard Operational Procedures--Fish Sampling* (Fischer & Combes 2011). Numeric biocriteria for fish are represented by the fIBI. Development of the fIBI is described in the document *Biological Criteria for Stream Fish Communities of Missouri* (Doisy *et al.* 2008).

The fIBI is a multi-metric index made up of nine individual metrics, which include:

- number (No.) of native individuals;
- No. of native darter species;
- No. of native benthic species;
- No. of native water column species;
- No. of native minnow species;
- No. of all native lithophilic species;
- percentage of native insectivore cyprinid individuals;
- percentage of native sunfish individuals; and,
- percentage of the three top dominant species.

Values for each metric, as directly calculated from the fish community sample, are converted to unitless scores of one, three, or five according to criteria in Doisy *et al.* (2008). The fIBI is then calculated by summing these unitless values for a total possible score of 45. Doisy *et al.* (2008) established an impairment threshold of 36 (where the 25th percentile of reference sites represent a score of 37), with values equal to or greater than 36 representing unimpaired communities and values less than 36 representing impaired communities. For more information regarding fIBI scoring, see Doisy *et al.* (2008).

Based on consultation between the Department and MDC, a fIBI impairment threshold value of 36 was used as the numeric biocriterion translator for making attainment decisions for aquatic life (Appendix C). However, because the work of Doisy *et al.* (2008) focused on streams 3rd to 5th order in size and fIBI was only validated for streams in the Ozark ecoregion (not for streams in the Central Plains or Mississippi Alluvial Basin), fIBI may

only be applied when assessing streams 3rd to 5th order in size from the Ozark ecoregion. Assessment procedures are outlined below.

Full Attainment

- For seven or fewer samples collected using MDC RAM fish community protocols, 75 percent of fIBI scores must be 36 or greater. Fauna achieving these scores are considered very similar to Ozark reference streams.
- For eight or more samples, the percentage scoring 36 or greater must be statistically similar to representative reference or control streams. To determine statistical similarity, a binomial probability Type I error rate (0.1) is calculated based on the null hypothesis that the test stream would have the same percentage (75 percent) of fIBI scores greater than 36 as reference streams. If the Type I error rate is more than the significance level α=0.1, the fish community is rated as unimpaired.

Non-Attainment

- For seven or fewer samples collected using MDC RAM fish community protocols, 75 percent of the fIBI scores must be lower than 36. Fauna achieving these scores are considered substantially different from regional reference streams.
- For eight or more samples, the percentage scoring 36 or less must be statistically dissimilar to representative reference or control streams. To determine statistical dissimilarity, a binomial probability Type I error rate is calculated based on the null hypothesis that the test stream would have the same percentage (75 percent) of fIBI scores greater than 36 as reference streams. If the Type I error rate is less than 0.1, the null hypothesis is rejected and the fish community is rated as impaired.

Data will be judged inconclusive when outcomes do not meet requirements for decisions of full or non-attainment.

With the exception of two subtle differences, use of the binomial probability for fish community samples will follow the example provided for macroinvertebrate samples in the previous section. First, instead of test stream samples being compared to reference streams of the same EDU, they will only be compared to reference streams from the Ozark ecoregion. Secondly, the probability of success used in the binomial distribution equation will always be set to 0.70 (see Appendix D for details).

Although 1st and 2nd order stream data will not be used to judge a stream as impaired for Section 303(d) purposes, the Department may use the above assessment procedures to judge 1st and 2nd order streams as unimpaired. Moreover, should samples contain fIBI scores less than 29 (Doisy *et al*. 2008), the Department may judge the stream as "suspected of impairment" using the above procedures.

Considerations for the Influence of Habitat Quality and Sample Representativeness

Low fIBI scores that are substantially different than reference streams could be the result of problems with water quality, habitat, or both. When low fIBI scores are determined, it is necessary to review additional information to differentiate between an impairment caused by water quality and one caused by habitat. Fish community sample collection is accompanied by a survey of physical habitat from the sampled reach. MDC sampling protocol for stream habitat follows procedures provided by Peck *et al.* (2006). With MDC guidance, the Department utilizes this habitat data and other available information to assure that a fish-based assessment of aquatic life attainment is only the result of water quality, and that an impairment resulting from poor or inadequate habitat is categorized as such. This section describes the procedures used to assure low fIBI scores are the result of water quality problems and not habitat degradation.

The information below outlines the Department's provisional method to identify unrepresentative samples and low fIBI scores of questionable habitat condition, and to ensure resulting fIBI scores are not used for Section 303(d) listing.

a) Following recommendations from the biocriteria workgroup, the Department will consult MDC about the habitat condition of particular streams when assessing low fIBI scores.

b) Samples may be considered for Section 303(d) listing ONLY if they were collected in the Ozark ecoregion, and, based upon best professional judgment from MDC staff, the samples were collected during normal representative conditions. Samples collected from the Central Plains and Mississippi Alluvial Basin cannot be appropriately evaluated and are excluded from Section 303(d) listing.

c) Only samples from streams 3rd to 5th order in size may be considered for Section 303(d) listing. Samples from 1st or 2nd order streams are excluded from Section 303(d) consideration; however, they may still be placed into Categories 2B and 3B if impairment is suspected, or into Categories 1, 2A, or 3A if sample scores indicate a stream is unimpaired. Samples from lower stream orders are surveyed under a different RAM Program protocol than 3rd to 5th order streams.

d) Samples that are ineligible for Section 303(d) listing include those collected from or in close proximity to losing streams, as defined by the Missouri Geological Survey. Additionally, ineligible samples may include those collected from streams with natural flow issues (such as streams reduced to predominately subsurface flow) that prevent good fIBI scores from being obtained, as determined through best professional judgment of MDC staff.

e) Fish IBI scores must be accompanied by a QCPH1 habitat index score. After analyzing meaningful habitat metrics and identifying samples where habitat metrics seemed to indicate potential habitat concerns, MDC developed a

provisional index named QCPH1. The QCPH1 comprises six sub-metrics indicative of substrate quality, channel disturbance, channel volume, channel spatial complexity, fish cover, as well as tractive force and velocity. QCPH1 values less than 0.39 indicate poor habitat, and values greater than 0.39 suggest adequate habitat.

The QCPH1 index is calculated as follows:

$$\text{QCPH1} = \left((\text{Substrate Quality} * \text{Channel Disturbance} * \text{Channel Volume} * \text{Channel Spatial Complexity} * \text{Fish Cover} * \text{Tractive Force \& Velocity})^{1/6}\right)$$

where sub-metrics are determined by:

Substrate Quality = [(embeddedness + small particles)/2] * [(filamentous algae + aquatic macrophyte)/2] * bedrock & hardpan

Channel Disturbance = concrete * riprap * inlet/outlet pipes * relative bed stability * residual pool observed to expected ratio

Channel Volume = [(dry substrate + width depth product + residual pool + wetted width)/4]

Channel Spatial Complexity = (coefficient of variation of mean depth + coefficient of variation of mean wetted width + fish cover variety)/3

Fish Cover = [(all natural fish cover + ((brush & overhanging vegetation + boulders + undercut bank + large woody debris)/4) + large types of fish cover)/3]

Tractive Force & Velocity = [(mean slope + depth * slope)/2]

Unimpaired fIBI samples (fIBI ≥36) with QCPH1 index scores below the 0.39 threshold value, or samples without a QCPH1 score altogether, are eliminated from consideration for Category 5 and, instead placed into Categories 2B or 3B should an impairment be suspected. Impaired fish communities (fIBI <36) with QCPH1 scores below 0.39 can be placed into Category 4C (non-discrete pollutant/habitat impairment). Impaired fish communities (fIBI <36) with adequate habitat scores (QCPH1 >0.39) can be placed into Category 5. Unimpaired fish communities (fIBI ≥36) and adequate habitat (QCPH1 >0.39) may be used to judge a stream as unimpaired.

Assessment of fish communities must be based on data coded Level 3 or 4 as described in Section II.C of this LMD. Data coded as Levels 3 and 4 represent environmental data with the greatest degree of assurance and indicate that assessments will include multiple samples from a single site or samples from multiple sites within a single reach.

Following the Department's provisional methodology, fish community samples available for assessment (using procedures in Appendix C & D) include only those from 3rd to 5th order Ozark Plateau streams with adequate habitat collected under normal representative conditions where there were no issues with inadequate flow or water volume.

IV. Other Biological Data

On a case by case basis, the Department may use biological data other than MSCI or fIBI scores for assessing attainment of aquatic life. Other biological data may include information on single indicator aquatic species that are ecologically or recreationally important, or individual measures of community health that respond predictably to environmental stress. Measures of community health could be represented by aspects of structure, composition, individual health, and processes of the aquatic biota. Examples could include measures of density or diversity of aquatic organisms, replacement of pollution intolerant taxa, or even the presence of biochemical markers.

Acute or Chronic Toxicity Tests

If toxicity tests are to be used as part of the weight of evidence, then accompanying media (water or sediment) analyses must accompany toxicity test results (e.g., if metals are a concern, then metals concentrations in the sediment sample used for an acute toxicity test must accompany the toxicity test results; or, if PAHs are a concern, then PAHs concentrations and the Total Organic Carbon (TOC) concentration must accompany toxicity test results). The organism, its developmental stage used for the toxicity test, and the duration of the test must also accompany the results.

Other biological data should be collected under a well vetted study that is documented in a scientific report, a weight of evidence approach should be established, and the report should be referenced in the 303(d) listing worksheet. If other biological data is a critical component of the community and has been adversely affected by the presence of a pollutant or stressor, then such data would indicate a water body is impaired. The Department's use of other biological data is consistent with EPA's policy on independent applicability for making attainment decisions, which is intended to protect against dismissing valuable information when diagnosing an impairment of aquatic life.

The use of other biological data is infrequent in water body assessments, but when available, it is usually assessed in combination with other information collected within the water body of interest. The Department will avoid using other biological data as the sole justification for a Section 303(d) listing; however, other biological data will be used as part of a weight of evidence analysis for making the most informed assessment decision.

V. <u>Toxic Chemicals</u>

Water

Standard acute or chronic bioassay procedures using freshwater aquatic fauna such as, but not limited to, Water Flea (*Ceriodaphnia dubia)*, Fathead Minnows (*Pimephales promelas*), Amphipod (*Hyalella azteca)*, or Rainbow Trout (*Oncorhynchus mykiss)*[24] will provide adequate evidence of toxicity for 303(d) listing purposes. Microtox® toxicity tests may be used to list a water as affected by "toxicity" only if data of another kind (freshwater toxicity tests, sediment or water chemistry, or biological sampling) also indicate water quality impairment.

For any given water, available data may occur throughout the system and/or be concentrated in certain areas. When the location of pollution sources are known, the Department reserves the right to assess data representative of impacted conditions separately from data representative of unimpacted conditions. Pollution sources include those that may occur at discrete points along a water body, or those that are more diffuse.

<u>Chronic Toxicity Events</u>

The parameters in WQS labeled as chronic criterion can be assessed in two ways:

1. Continuous Data Sondes
   - For data that has been collected consecutively over time, (e.g., a data sonde collecting information every 15 minutes for a two-week time period) the data will be used as is after QA/QC procedures.
2. Grab Samples
   - For samples that have not been collected consecutively, (e.g., a grab sample collected once a week) the hydrologic flow conditions of the stream or the closest USGS gage will be used to verify the sample was collected during stable flow conditions. If the flow conditions were <u>unstable,</u> then the sample <u>will not be assessed</u> against the chronic criterion. If the flow conditions were <u>stable,</u> then the sample <u>will be assessed</u> against the chronic criterion. There are three categories of stable flow conditions: High, Medium, and Low.
     i. High Stable Flow - greater than the 50th percentile exceedance flow, and less than 10 percent change in flow over a 48-hour period.
     ii. Medium Stable Flow - between the 90th percentile exceedance flow and the 50th percentile exceedance flow, and less than 15 percent change in flow over a 48-hour period.
     iii. Low Stable Flow - less than the 90th percentile exceedance flow or less than one cubic foot per second, and less than 20 percent change in flow over a 48-hour period.

[24] Reference 10 CSR 20-7.015(9)(L) for additional information

Sediment

For toxic chemicals occurring in benthic sediments, a geometric mean will be calculated for specific toxins from an adequate number of samples. The calculated geometric mean will then be compared to the corresponding Probable Effect Concentration (PEC) given by MacDonald *et al.* (2000). The PEC is the level of a pollutant above which harmful effects on the aquatic community are likely to be observed. Refer to MacDonald *et al.* (2000) for the estimated accuracy of individual PECs to predict toxicity. For all metals except arsenic, pollutant geometric means will be compared to 150 percent of the recommended PEC values. These comparisons should meet confidence requirements applied elsewhere in this LMD. When multiple metal contaminants occur in sediment, toxicity may occur even though the level of each individual pollutant does not reach toxic levels. The method of estimating the synergistic effects of multiple metals in sediments is described below.

The sediment PECs given by MacDonald *et al.* (2000) are based on additional data assumptions. Those assumptions include a 1 percent TOC content and that the sample has been sieved to less than 2 mm.

The Department uses 150 percent of the PEC values to account for some variability in our assessment of sediment toxicity. See the ***Equilibrium Partitioning Sediment Benchmark*** section further below for more information on TOC and sulfide considerations for metals toxicity in sediment.

For the sample sieving assumption, the Department will use non-sieved (bulk) sediment concentrations for screening level data (Data Code One). Current impairments that have used bulk sediment data as evidence for impairment will remain on the 303(d) list until sieved data can be collected to show either that the water body should remain on the list or that the sieved concentrations are below the 150 percent PEC values. Data that has been sieved to less than 2 mm or smaller will be used for comparison to the 150 percent PEC values.

The Meaning of the Sediment Quotient and How to Calculate It

Although sediment criteria in the form of PECs are given for several individual contaminants, it is recognized that when multiple contaminants occur in sediment, toxicity may occur even though the level of each individual pollutant does not reach toxic levels. The MacDonald *et al.* (2000) method for estimating the synergistic effects of multiple pollutants in sediment utilizes the calculation of a Probable Effects Concentration Quotient (PECQ). PECQs greater than 0.75 will be judged as toxic.

This calculation is made by dividing the pollutant concentration in the sample by the PEC value for that pollutant. For single samples, the quotients are summed, and then normalized by dividing that sum by the number of pollutants in the formula. When multiple samples are available, the geometric mean (as calculated for specific pollutants) will be placed in the numerator position for each pollutant included in the equation.

Example - A sediment sample contains the following results in mg/kg:
Arsenic 2.5, Cadmium 4.5, Copper 17, Lead 100, Zinc 260.

The PEC values for these five pollutants in respective order are:
33, 4.98, 149, 128, and 459 mg/kg.

PECQ = [(2.5/33) + (4.5/4.98) + (17/149) + (100/128) + (260/459)]/5 = 0. 488

Using PECQ to Judge Metals Toxicity

Based on research by MacDonald *et al.* (2000), 83 percent of sediment samples with a PECQ less than 0.5 were non-toxic; while 85 percent of sediment samples with a PECQ greater than 0.5 were toxic. Therefore, to accurately assess the synergistic effects of sediment contaminants on aquatic life, the Department will judge a PECQ greater than 0.75 as toxic**.**

Using Total PAHs to Judge Toxicity

PAHs are organic compounds containing only carbon and hydrogen that form aromatic rings (cyclic molecular shapes). PAHs in the environment can be of natural origin, such as from coal and oil deposits, or man-made (anthropogenic) from the use and breakdown hydrocarbon compounds. There are three different sources of hydrocarbon compounds: plants (phytogenic), petroleum (petrogenic), and the combustion of petroleum, wood, coal, etc. (pyrogenic). In streams, the most common sources of PAHs are from anthropogenic sources such as sealants (coal tar) and other treatments of roads, driveways, and parking lots.

Mount *et al.* (2003) indicates that individual PAH guidelines (PECs) are based on the samples also having an elevated presence of other PAHs. This potentially overestimates the actual toxicity of an individual PAH PEC value. A *Total* PAH guideline (e.g., PEC) reduces variability and provides a better representation of toxicity when compared to individual PAH PECs.

Based on research by MacDonald *et al.* (2000), 81.5 percent of sediment samples with a Total PAH value less than 22.8 mg/kg were non-toxic; while 100 percent of sediment samples with a Total PAH value greater than 22.8 mg/kg were toxic. Therefore, to accurately assess the toxicity to aquatic life of total PAHs in sediment, the Department will judge Total PAH values greater than 150 percent of the PEC value (34.2 mg/kg) as toxic.

What compounds are considered in calculating Total PAHs and how will they be compared to the 150 percent PEC value?

To calculate Total PAHs for a sample, Mount *et al.* (2003) recommends following the EPA Environmental Monitoring Assessment Program's definition of Total PAHs. This definition includes 34 PAH compounds; 18 parent PAHs and 16 alkylated PAHs (see Table 3 for a list of these compounds). Mount *et al.* (2003) indicates that using less than the 34 PAH compounds can underestimate the toxicity of PAHs in sediment. TOC has the potential to

affect the bioavailability of PAHs. Organic carbon can provide a binding phase for PAHs, but the extent of that binding capacity is unknown. Through the weight of evidence approach (see Section D. II.), the Department will consider the effects of TOC on a case by case basis.

Only 14–18 of the 34 PAH compounds are commonly requested for analysis. Therefore, the process to judge toxicity due to Total PAHs is as follows:

- When samples are analyzed for fewer than the 34 PAH compounds:
    - If the sum of the geometric means for more than one sample of the compounds is greater than the 150 percent PEC, then the sample(s) will be judged as toxic.
    - If the sum of the geometric means for more than one sample of the compounds is greater than the 100 percent but less than 150 percent of the PEC, then the sample(s) will be judged as inconclusive.
    - If the sum of the geometric means for more than one sample of the compounds is less than the 100 percent PEC, then the values will be judged as non-toxic.
- When samples are analyzed for all 34 PAH compounds:
    - If the sum of the geometric means for more than one sample of the compounds is greater than the 150 percent PEC, then the sample(s) will be judged as toxic.
    - If the sum of the geometric means for more than one sample of the compounds is less than the 150% PEC, then the values will be judged as non-toxic.

Table 3. List of 34 polycyclic aromatic hydrocarbon (PAH) compounds that are considered for the calculation of Total PAHs.

Parent PAHs (18)	Alkylated PAHs (16)
Acenaphthene	C1-Benzanthracene/chrysenes
Acenphthylene	C1-Fluorenes
Anthracene*	C1-Naphthalenes
Benz(a)anthracene*	C1-Phenanthrene/anthracenes
Benzo(a)pyrene*	C1-Pyrene/fluoranthenes
Benzo(b)fluoranthene	C2-Benzanthracene/chrysenes
Benzo(e)pyrene	C2-Fluorenes
Benzo(g,h,i)perylene	C2-Naphthalenes
Benzo(k)fluoranthene	C2-Phenanthrene/anthracenes
Chrysene*	C3-Benzanthracene/chrysenes
Dibenz(a,h)anthracene	C3-Fluorenes
Fluoranthene*	C3-Naphthalenes
Fluorene*	C3-Phenanthrene/anthracenes
Indeno(1,2,3-cd)pyrene	C4-Benzanthracene/chrysenes
Naphthalene*	C4-Naphthalenes
Perylene	C4-Phenanthracene/anthracenes
Phenanthrene*	
Pyrene*	

**Listed in Table 3 of MacDonald et al. (2000)*

Equilibrium Partitioning Sediment Benchmark (ESB) Data

Another type of analysis for sediment metal toxicity is based on the EPA (2006) paper that discusses ESBs and their uses. The Department does not currently collect ESB data but will consider ESB data collected by other entities under the weight of evidence approach. To be considered, the data must be accompanied by the name of the laboratory having completed the analysis, along with a copy of their laboratory procedures and QC documentation. Sieved sediment samples will be judged as toxic for metals in sediment if the sum of the simultaneously extracted metals minus acid volatile sulfides, divided by the fractional organic carbon [(ΣSEM-AVS)/FOC] is greater than 3000. If additional sieved sediment samples also show toxicity for a particular metal(s), then that particular metal(s) will be identified as the cause for toxicity.

Pictorial representations (flow charts) for how these different sediment toxicity procedures could be used in the weight of evidence analysis are displayed in Appendix E.

VI. Duration of Assessment Period

Except where the assessment period is specifically noted in Appendix B, the time period during which data will be used in making the assessments will be determined by data age and data code considerations, as well as representativeness considerations such as those described in footnote 14.

VII. Assessment of Tier Three Waters

Waters given Tier Three Protection by the antidegradation rule at 10 CSR 20-7.031(3) shall be considered impaired if data indicate water quality has been reduced in comparison to its historical quality. Historical water quality is determined from past data that best describes a water's quality following promulgation of the antidegradation rule and at the time the water was given Tier Three Protection.

Historical data gathered at the time a water body was given Tier Three Protection will be used if available. Because historical data may be limited, the historical quality of waters may be determined by comparing data from the assessed segment with data from a "representative" segment. A representative segment is a body or stretch of water that best reflects the conditions that probably existed at the time the antidegradation rule first applied to the waters being assessed. Examples of possible representative data include data from stream segments upstream of assessed segments that receive discharges, and data from other water bodies in the same ecoregion that have similar watershed and landscape characteristics. These representative stream segments would also be characterized as having the quality and quantity of receiving discharges similar to those of the historic discharges of the assessed segment. The assessment may also use data from the assessed segment gathered between the time the Tier Three Protection was initiated and the last known time in which

upstream discharges, runoff, and watershed conditions remained the same, provided that the data do not show any significant trends of declining water quality during that period.

The data used in the comparisons will be tested for normality and an appropriate statistical test will be applied. The null hypothesis for statistical analysis will be that water quality at the test segment and representative segment are the same. This will be a one-tailed test (the test will consider only the possibility that the assessed segment has poorer water quality) with the alpha level (α) of 0.1. This means that the test must show greater than a 90 percent probability that the assessed segment has poorer water quality than the representative segment before the assessed segment can be listed as impaired.

VIII. Other Types of Information

1. *Observation and evaluation of waters for noncompliance with state narrative water quality criteria*. Missouri's general (narrative) water quality criteria, as described in 10 CSR
   20-7.031 Section (4), may be used to evaluate waters when a quantitative (numeric) value cannot be applied to the pollutant. These narrative criteria apply to both classified and unclassified waters and prohibit the following in waters of the state:
   a. Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly, or harmful bottom deposits or prevent full maintenance of beneficial uses;
   b. Waters shall be free from oil, scum, and floating debris in sufficient amounts to be unsightly or prevent full maintenance of beneficial uses;
   c. Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or prevent full maintenance of beneficial uses;
   d. Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal, or aquatic life;
   e. Waters shall maintain a level of water quality at their confluences to downstream waters that provides for the attainment and maintenance of the WQS of those downstream waters, including waters of another state;
   f. There shall be no significant human health hazard from incidental contact with the water;
   g. There shall be no acute toxicity to livestock or wildlife watering;
   h. Waters shall be free from physical, chemical, or hydrologic changes that would impair the natural biological community; and
   i. Waters shall be free from used tires, car bodies, appliances, demolition debris, used vehicles or equipment, and solid waste as defined in Missouri's Solid Waste Law, section 260.200, RSMo, except where the use of such materials is specifically permitted pursuant to sections 260.200–260.247, RSMo.

2. *Evaluation of aquatic habitat to further inform assessment decisions.* Habitat assessment protocols for wadeable streams have been established and are conducted in conjunction with sampling aquatic macroinvertebrates and fish. Methods for evaluating aquatic macroinvertebrate and fish community data include assessment procedures that account for the presence or absence of representative habitat quality. The Department will not use habitat data alone for assessment purposes.

Other 303(d) Listing Considerations

- *Adding to the Existing List or Expanding the Scope of Impairment to* a *Previously Listed Water Body:*

  Following the guidelines set forth in this LMD, the listed portion of an impaired water body may be increased, or one or more new pollutants may be added to a listing, based on more recent monitoring data. Waters not previously listed may also be added to the list under the guidelines set forth in this LMD.

- *Deleting from the Existing List or Decreasing the Scope of Impairment to* a *Previously Listed Water Body:*

  Following the guidelines set forth in this LMD, the listed portion of an impaired water body may be decreased, or one or more pollutants may be deleted from the listing, based on more recent monitoring data (see Appendix D). Waters may also be completely removed from the list for several reasons;[25] the most common being that the water is attaining WQS, or that the water has an EPA approved TMDL or permit-in-lieu of a TMDL.

- *Listing Length of Impaired Segments:*

  The meaasured length of a 303(d) listing is currently based on the Waterbody Identification (WBID) length from Missouri's WQS. The Department is using the WBID as the assessment unit to report to EPA. When the Department gains the database capability to further refine assessment units into segments smaller than WBIDs, while maintaining a transparent link to the WBID and Missouri's WQS, then the Department will do so. Upon further refinement of the assessment unit, the Department will provide justifications for dividing WBIDs into smaller assessment units on the assessment worksheets and will welcome discussion of such divisions during the public notice period.

Prioritization of Waters for TMDL Development

Section 303(d) of the CWA and federal regulation 40 CFR 130.7(b)(4) requires states to submit a priority ranking of waters requiring TMDLs. The Department will prioritize development of TMDLs based on several variables including:

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[25] See, "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act". USEPA, Office of Water, Washington DC.

- social impact/public interest and risk to public health;
- complexity and cost (including consideration of budget constraints);
- availability of data of sufficient quality and quantity for TMDL modeling;
- court orders, consent decrees, or other formal agreements;
- source of impairments;
- existence of appropriate numeric quality criteria;
- implementation potential and amenability of the problem to treatment; and
- Integrated Planning efforts by municipalities and other entities.

The Department's TMDL schedule and prioritization are included on the 303(d) list. The TMDL Program develops the TMDL schedule and framework. More information is available from the following website: http://www.dnr.mo.gov/env/wpp/tmdl/.

Resolution of Interstate/International Disagreements

The Department will review the draft 303(d) lists of all states with which it shares a border or other interstate waters (e.g., Missouri River, Mississippi River, Des Moines River, St. Francis River). Where the listing in another state is different than the one in Missouri for the same water body, the Department will request the data and listing justification from the other state. The data will be reviewed following the evaluation guidelines in this LMD. The draft Missouri 303(d) list may be subject to change pending the results of any such evaluation.

Statistical Considerations

The most recent EPA guidance on the use of statistics in the 303(d) LMD is given in Appendix A. Within this guidance are three major recommendations regarding statistics:

- Provide a description of analytical tools used by the state under various circumstances;
- Explain the various circumstances under which the burden-of-proof is placed on proving the water is impaired and when it is placed on proving the water is unimpaired (applicable to hypothesis testing); and
- Explain the level of statistical significance (α) used under various circumstances.

- Description of Analytical Tools

  Appendix D describes the analytical tools the Department will use to determine whether a water body is impaired and whether or when a listed water body is no longer impaired.

- Rationale for the Burden-of-Proof

  Hypothesis testing is a common statistical analysis in which an assumed observation, or alternate hypothesis, is tested by comparison with a null hypothesis. The procedure involves first stating a testable observation (alternate hypothesis), such as, "The most frequently seen

clothing color at a St. Louis Cardinals game is red," and then the opposite, which becomes the null hypothesis ("Red is not the most frequently seen clothing color at a St. Louis Cardinals game."). A statistical test is then applied to the data (e.g., a sample of the predominant clothing color worn by 200 fans at a St. Louis Cardinals game on July 12, 2019) and based on the result of that analysis, one of the two hypotheses is chosen as correct.

In hypothesis testing, the burden-of-proof is always on the alternate hypothesis. In other words, the data must be especially convincing to make us reject the null hypothesis and accept the alternate hypothesis as being true. How convincing the data must be is stated as the "significance level" of the test. A significance level of $\alpha = 0.10$ means that there must be at least a 90 percent probability that the alternate hypothesis is true before we can accept it and reject the null hypothesis.

For analysis of a specific kind of data, either the test significance level or the statement of null and alternative hypotheses, or both, can be varied to achieve the desired level of statistical rigor. The Department has chosen to maintain a consistent set of null and alternate hypotheses for all statistical tests. The null hypothesis will be that the water body in question is unimpaired, and the alternate hypothesis will be that it is impaired. The Department's desired level of statistical rigor will be accomplished by varying the test significance level. For determining impairment (Appendix D), significance levels are set at either $\alpha = 0.1$ or $\alpha = 0.4$, meaning the data must show at minimum a 90 percent or 60 percent probability, respectively, that the water body is impaired. However, if the Department retained these same significance levels to determine when an impaired water body has been restored to an unimpaired status (Appendix D), some undesirable results can occur.

For example, when using a significance level of $\alpha = 0.1$ for determining both impairment and non-impairment, if sample data indicate a stream had a 92 percent probability of being impaired, it would be rated as impaired. If subsequent data were collected and added to the database, and the data now showed the water had an 88 percent probability of being impaired, it would be rated as unimpaired. Judging a water body with only a 12 percent probability of being unimpaired as unimpaired is clearly a poor decision. To correct this problem, the Department will use a test significance level of $\alpha = 0.4$ for some analytes and $\alpha = 0.6$ for others. This will increase Department confidence in determining WQS compliance to 40 percent and 60 percent, respectively, under the worst-case conditions.

- <u>Level of Significance Used in Tests</u>

Significance levels are chosen with two concerns in mind. The first concern involves matching decision error rates with the severity of the consequences of committing a decision error. The second concern addresses the need to balance, within practicality, Type I (the error of rejecting a null hypothesis when it is actually true) and Type II (the error of not rejecting a null hypothesis when the alternative hypothesis is true) error rates. For relatively small sample numbers, the disparity between Type I and Type II errors can be large. Tables 4 and 5 display calculated error rates using the binomial distribution for two very similar situations. Type I and Type II error rates are based on a stream with a 10 percent and a 15 percent WQS exceedance

rate, respectively. Note that when sample size remains the same (Table 4), Type II error rates increase as Type I error rates decrease. Also note that for a given Type I error rate, the Type II error rate declines as sample size increases (Table 5).

Table 4. Effects of Type I error rates on Type II error rates when sample sizes are equal. Type I and Type II error rates are based on a stream with a 10 percent and a 15 percent WQS exceedance rate, respectively.

Total No. of Samples	No. Samples Meeting Std.	Type I Error Rate	Type II Error Rate
18	17	0.850	0.479
18	16	0.550	0.719
18	15	0.266	0.897
18	14	0.098	0.958
18	13	0.028	0.988

Table 5. Effects of Type I error rates and sample size on Type II error rates. Type I and Type II error rates are based on a stream with a 10 percent and a 15 percent WQS exceedance rate, respectively.

Total No. of Samples	No. Samples Meeting Std.	Type I Error Rate	Type II Error Rate
6	5	0.469	0.953
11	9	0.303	0.930
18	15	0.266	0.897
25	21	0.236	0.836

- Use of the Binomial Probability Distribution for Interpretation of the 10 Percent Rule

There are two options for assessing data for compliance with the 10 percent rule[26]. One is to simply calculate the percent of time the criterion value is not met, and to judge the water to be impaired if this value is greater than 10 percent. The second method is to use an evaluative procedure that can review the data and provide a probability statement regarding compliance with the 10 percent rule. Since the latter option allows assessment decisions relative to specific test significance levels and the former option does not, the latter option is preferred. The Department uses the binomial probability distribution and calculation of the Type I error rate as the evaluative procedure.

[26]Guidelines for preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates (1997) Supplement Volume 2. Refer to page 80, section on conventionals (dissolved oxygen, pH, temperature). https://www.epa.gov/sites/production/files/2015-09/documents/guidelines_for_preparation_of_the_comprehensive_state_water_quality_assessments_305b_reports_and_electronic_updates_1997_supplement-volume2.pdf#page=80

- <u>Other Statistical Considerations</u>

  Prior to calculating confidence limits, the normality of the dataset will be evaluated. If normality is improved by data transformation, the confidence limits will be calculated on the transformed data.

  Time of sample collection may be biased and interfere with an accurate measurement of the frequency of criterion exceedance. Data sets composed mainly or entirely of storm water data or data collected only during a season when water quality problems are expected could result in a biased estimate of the true exceedance frequency. In these cases, the Department may use methods to estimate the true annual frequency and display these calculations whenever they result in a change in the impairment status of a water body.

  For waters judged to be impaired based on biological data where data evaluation procedures are not specifically noted in Table 1, the statistical procedure used, test assumptions, and results will be reported.

- <u>Examples of Statistical Procedures</u>

  Two Sample "t" Test for Color

  Null Hypothesis: The amount of color is no greater in a test stream than in a control stream. As stated, this is a one-sided test, meaning that we are only interested in determining whether or not the color level in the test stream is greater than in a control stream. If the null hypothesis had been "the amount of color is different in the test and control streams," we would have been interested in determining if the amount of color was either less than or greater than the control stream, a two-sided test.

  Significance Level: $\alpha = 0.10$

  Data Set: Platinum-Cobalt color scale data for the test stream and a control stream. Samples were collected at each stream on the same date.

Test Stream (T)	70	45	35	45	60	60	80
Control Stream (C)	50	40	20	40	30	40	75
Difference (T-C)	20	5	15	5	30	20	5

  Statistics for the Difference: Mean = 14.28, standard deviation = 9.76, n = 7
  Calculated "t" value = (square root of n)(mean)/standard deviation = **3.86**
  Tabular "t" value is taken from a table of the "t" distribution for 2 alpha (0.20) and n-1 degrees of freedom. Tabular "t" = **1.44**

  Since the calculated "t" value is greater than tabular "t" value, we reject the null hypothesis and conclude that the amount of color in the test stream is greater than the control stream (i.e., the test stream is impaired by color).

Statistical Procedure for Mercury in Fish Tissue

Data Set (in µg/Kg): 130, 230, 450. Mean = 270, Standard Deviation = 163.7
If the 60% Lower Confidence Limit (LCL) Interval = the sample mean minus the quantity; and ((0.253)(163.7)/square root 3) = 23.9. Then, the 60 percent LCL Interval is 246.1 µg/Kg.

The criterion value is 300 µg/Kg. Since the 60 percent LCL Interval is less than the criterion value, the water is judged to be unimpaired by mercury in fish tissue, and the water body is placed in either Category 2B or 3B.

References

Barbour, M.T., J. Gerritsen, G.E. Griffith, R. Frydenborg, E. McCarron, J.S. White, M.L. Bastian. 1996. A framework for biological criteria for Florida streams using benthic macroinvertebrates. Journal of the North American Benthological Society 15(2): 185-211.

Center for Watershed Protection. 2003. Watershed Protection Research Monograph No.1: impacts of impervious cover on aquatic systems. Center for Watershed Protection, Ellicot City, MD.

Doisy, K.E., C.F. Rabeni, M.D. Combes, and R.J. Sarver. 2008. Biological criteria for stream fish communities of Missouri. Final Report to the United States Environmental Protection Agency. Missouri Cooperative Fish and Wildlife Research Unit, Columbia, MO. 91.

Hughes, R.M., D.P. Larsen, and J.M. Omernik. 1986. Regional reference sites: a method for assessing stream pollution. Environmental Management, 10(5): 625-629.

Ohio EPA. 1990. The use of biocriteria in the Ohio EPA Surface Water Monitoring and Assessment Program. Columbus, OH.

Fischer, S. and M. Combes. 2011. Resource Assessment and Monitoring Program: standard operating procedures - fish sampling. Missouri Department of Conservation, Jefferson City, MO.

MacDonald, D.D, Ingersoll, C. G., Berger, T. A. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contamination Toxicology. 39, 20-31.

Missouri Department of Natural Resources. 2002. Biological criteria for wadeable/perennial streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32.

Missouri Department of Natural Resources. 2015. Semi-quantitative macroinvertebrate stream bioassessment. Missouri Department of Natural Resources, Environmental Services Program, Jefferson City, MO. 29.

Missouri Department of Natural Resources. 2016a. Stream habitat assessment. Missouri Department of Natural Resources, Environmental Services Program, Jefferson City, MO. 40.

Missouri Department of Natural Resources. 2016b. Taxonomic Levels for macroinvertebrate identifications. Division of Environmental Quality, Environmental Services Program, Jefferson City, MO. 39.

Missouri Resource Assessment Partnership. 2005. Missouri Landcover Classification Project. Available at: https://morap.missouri.edu/index.php/land-cover/

Mount, D. R., Ingersoll, C. G. and McGrath, J. A. 2003. Approaches to developing sediment quality guidelines for PAHs. PAHs: An Ecotoxicological Perspective (ed. P.E.T. Douben), John Wiley & Sons, Ltd, Chichester, UK.

NLCD. 2011. Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K. Completion of the 2011 National Land Cover Database for the conterminous United States - representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing*, 81(5), 345-354.

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006.

Environmental Monitoring and Assessment Program - surface waters western pilot study: field operation manual for wadeable streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

US EPA. 1996. Biological criteria: technical guidance for streams and small rivers. EPA 822-B-96-001. Office of Water, Washington D.C. 162.

US EPA. 2005. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: metal mixtures (cadmium, copper, lead, nickel, silver and zinc). EPA-600-R-02-011. Office of Research and Development. Washington, DC 20460.

Appendix B

Excerpt from *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act.* July 29, 2005. US EPA pp. 39-41.

The document can be read in its entirety from the US. EPA web site:
http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/2006irg-report.pdf

How should statistical approaches be used in attainment determinations?

The state's methodology should provide a rationale for any statistical interpretation of data for the purpose of making an assessment determination.

Description of statistical methods to be employed in various circumstances

The methodology should provide a clear explanation of which analytic tools the state uses and under which circumstances. EPA recommends that the methodology explain issues such as the selection of key sample statistics (arithmetic mean concentration, median concentration, or a percentile), null and alternative hypotheses, confidence intervals, and Type I and Type II error thresholds. The choice of a statistic tool should be based on the known or expected distribution of the concentration of the pollutant in the segment (e.g., normal or log normal) in both time and space.

Past EPA guidance (1997 305(b) and 2000 CALM) recommended making non-attainment decisions, for "conventional pollutants[27]" — TSS, pH, BOD, fecal coliform bacteria, and oil and grease — when more than "10% of measurements exceed the water quality criterion." (However, EPA guidance has not encouraged use of the "10% rule" with other pollutants, including toxics.) Use of this rule when addressing conventional pollutants, is appropriate if its application is consistent with the manner in which applicable WQC are expressed. An example of a WQC for which an assessment based on the ten percent rule would be appropriate is the EPA acute WQC for fecal coliform bacteria, applicable to protection of water contact recreational use. This 1976-issued WQC was expressed as, "...no more than ten percent of the samples exceeding 400 CFU per 100 ml, during a 30-day period." Here, the assessment methodology is clearly reflective of the WQC.

On the other hand, use of the ten percent rule for interpreting water quality data is usually not consistent with WQC expressed either as: 1) instantaneous maxima not to be surpassed at any time, or 2) average concentrations over specified times. In the case of "instantaneous maxima (or minima) never to occur" criteria use of the ten percent rule typically leads to the belief that segment conditions are equal or better than specified by the WQC, when they in fact are considerably worse. (That is, pollutant concentrations are above the criterion-concentration a far greater proportion of the time than specified by the WQC.) Conversely, use of this decision

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[27] There are a variety of definitions for the term "conventional pollutants." Wherever this term is referred to in this guidance, it means "a pollutant other than a toxic pollutant."

rule in concert with WQC expressed as average concentrations over specific times can lead to concluding that segment conditions are worse than WQC, when in fact they are not.

If the state applies different decision rules for different types of pollutants (e.g., toxic, conventional, and non-conventional pollutants) and types of standards (e.g., acute vs. chronic criteria for aquatic life or human health), the state should provide a reasonable rationale supporting the choice of a particular statistical approach to each of its different sets of pollutants and types of standards.

1. *Elucidation of policy choices embedded in selection of particular statistical approaches and use of certain assumptions EPA strongly encourages states to highlight policy decisions implicit in the statistical analysis that they have chosen to employ in various circumstances. For example, if hypothesis testing is used, the state should make its decision-making rules transparent by explaining why it chose either "meeting WQS" or "not meeting WQS" as the null hypothesis (rebuttable presumption) as a general rule for all waters, a category of waters, or an individual segment. Starting with the assumption that a water is "healthy" when employing hypothesis testing means that a segment will be identified as impaired, and placed in Category 4 or 5, only if substantial amounts of credible evidence exist to refute that presumption. By contrast, making the null hypothesis "WQS not being met" shifts the burden of proof to those who believe the segment is, in fact, meeting WQS.*

Which "null hypothesis" a state selects could likely create contrasting incentives regarding support for additional ambient monitoring among different stakeholders. If the null hypothesis is "meeting standards," there were no previous data on the segment, and no additional existing and readily available data and information are collected, then the "null hypothesis" cannot be rejected, and the segment would not be placed in Category 4 or 5. In this situation, those concerned about possible adverse consequences of having a segment declared "impaired" might have little interest in collection of additional ambient data. Meanwhile, users of the segment would likely want to have the segment monitored, so they can be ensured that it is indeed capable of supporting the uses of concern. On the other hand, if the null hypothesis is changed to "segment not meeting WQS," then those that would prefer that a particular segment not be labeled "impaired" would probably want more data collected, in hopes of proving that the null hypothesis is not true.

Another key policy issue in hypothesis testing is what significance level to use in deciding whether to reject the null hypothesis. Picking a high level of significance for rejecting the null hypothesis means that great emphasis is being placed on avoiding a Type I error (rejecting the null hypothesis, when in fact, the null hypothesis is true). This means that if a 0.10 significance level is chosen, the state wants to keep the chance of making a Type I error at or below ten percent. Hence, if the chosen null hypothesis is "segment meeting WQS," the state is trying to keep the chance of saying a segment is impaired – when in reality it is not – under ten percent.

An additional policy issue is the Type II errors (not rejecting the null hypothesis, when it should have been). The probability of Type II errors depends on several factors. One key factor is the number of samples available. With a fixed number of samples, as the probability of Type I error decreases, the probability of a Type II error increases. States would ideally collect enough samples so the chances of making Type I and Type II errors are simultaneously small. Unfortunately, resources needed to collect such numbers of samples are quite often not available.

The final example of a policy issue that a state should describe is the rationale for concentrating limited resources to support data collection and statistical analysis in segments where there are documented water quality problems or where the combination of nonpoint source loadings and point source discharges would indicate a strong potential for a water quality problem to exist.

EPA recommends that, when picking the decision rules and statistical methods to be utilized when interpreting data and information, states attempt to minimize the chances of making either of the two following errors:

- *Concluding the segment is impaired, when in fact it is not, and*
- *Deciding not to declare a segment impaired, when it is in fact impaired.*

States should specify in their methodology what significance level they have chosen to use, in various circumstances. The methodology would best describe in "plain English" the likelihood of deciding to list a segment that in reality is not impaired (Type I error if the null hypothesis is "segment not impaired"). Also, EPA encourages states to estimate, in their assessment databases, the probability of making a Type II error (not putting on the 303(d) list a segment that in fact fails to meet WQS), when: 1) commonly-available numbers of grab samples are available, and 2) the degree of variance in pollutant concentrations are at commonly encountered levels. For example, if an assessment is being performed with a WQC expressed as a 30-day average concentration of a certain pollutant, it would be useful to estimate the probability of a Type II error when the number of available samples over a 30 day period is equal to the average number of samples for that pollutant in segments state-wide, or in a given group of segments, assuming a degree of variance in levels of the pollutant often observed over typical 30 day periods.

Appendix C

METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WQS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS[i]	Notes
Overall use protection (all designated uses)	No data. Evaluated based on similar land use/geology as stream with water quality data.	Not applicable	Given same rating as monitored stream with same land use and geology.	**Data Type Note:** This data type is used only for wide-scale assessments of aquatic biota and aquatic habitat for 305(b) Report purposes. This data type is not used in the development of the 303(d) list.
Any designated uses	No data available or where only effluent data is available. Results of dilution calculations or water quality modeling.	Not applicable	Where models or other dilution calculations indicate noncompliance with allowable pollutant levels and frequencies noted in this table, waters may be added to Category 3B and considered high priority for water quality monitoring.	
Protection of Aquatic Life	Dissolved oxygen, water temperature, pH, total dissolved gases, oil and grease	1-4	Full: No more than 10 percent of all samples exceed criterion. Non-Attainment: Requirements for full attainment not met. Requirements: A minimum sample size of 10 samples during the assessment period (see Section VI above).	**Compliance with WQS Note:** Some sampling periods are wholly or predominantly during the critical period of the year when criteria violations occur. Where the monitoring program presents good evidence of a demarcation between seasons where criteria exceedances occur and seasons when they do not, the 10 percent exceedance rate will be based on an annual estimate of the frequency of exceedance. Continuous (e.g., sonde) data with a quality rating of excellent or good will be used for assessments.
Protection of Aquatic Life	Chemical (toxins)	1-4	Full: No more than one acute toxic event in three years that results in a documented die-off of aquatic life such as fish, mussels, and crayfish (does not include die-offs due to natural origin). No more than one exceedance of acute or chronic criterion in the last three years for which data is available. Non-Attainment: Requirements for full attainment not met.	**Compliance with WQS Note:** For hardness-based metals with eight or fewer samples, the hardness value associated with the sample will be used to calculate the acute or chronic thresholds. For hardness-based metals with more than eight samples, the hardness definition provided in state water quality standards will be used to calculate the acute and chronic thresholds.

Appendix C

METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WQS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS[i]	Notes
Protection of Aquatic Life	Lake nutrients (total phosphorus, total nitrogen, chlorophyll-a)	1-4	Full: Nutrient levels do not exceed WQS following procedures stated in Appendix D and F. Non-Attainment: Requirements for full attainment not met.	
Human Health - Fish Consumption	Chemical (water)	1-4	Full: Water quality does not exceed WQS following procedures stated in Appendix D. Non-Attainment: Requirements for full attainment not met.	
Drinking Water Supply (Raw)	Chemical (toxics)	1-4	Full: WQS not exceeded following procedures stated in Appendix D. Non-Attainment: Requirements for full attainment not met.	**Designated Use Note:** Raw water is water from a stream, lake or groundwater prior to treatment in a drinking water treatment plant.
Drinking Water Supply (Raw)	Chemical (sulfate, chloride, fluoride)	1-4	Full: WQS not exceeded following procedures stated in Appendix D. Non-Attainment: Requirements for full attainment not met.	
Drinking Water Supply (Finished)	Chemical (toxics)	1-4	Full: No Maximum Contaminant Level (MCL) violations based on Safe Drinking Water Act data evaluation procedures. Non-Attainment: Requirements for full attainment not met.	**Compliance with WQS Note:** Finished water data will not be used for analytes where water quality problems may be caused by the drinking water treatment process such as Trihalomethane (THM) formation, or problems that may be caused by distribution (bacteria, lead, copper).
Whole Body & Secondary Contact Recreation	*E. coli* count	2-4	Where there are at least five samples per year taken during the recreational season: Full: WQS not exceeded as a geometric mean, in any of the last three years for which data is available, for samples collected during seasons for which bacteria criteria apply. Non-Attainment: Requirements for full attainment not met.	**Compliance with WQS Note:** A geometric mean of 206 cfu/100 ml for *E. coli* will be used as a criterion for Category B Recreational Waters.

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METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WQS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WQS[i]	Notes
Whole Body Contact Recreation - Losing Streams	*E. coli* count	1-4	Full: No more than 10 percent of all samples exceed criterion. Non-Attainment: Requirements for full attainment not met. The criterion for *E. coli* is 126 counts/100 ml. 10 CSR 20-7.031 (4)(C)	
Irrigation, Livestock and Wildlife Water	Chemical (metals, fluoride)	1-4	Full: WQS not exceeded following procedures stated in Appendix D. Non-Attainment: Requirements for full attainment not met.	

[i] See section on Statistical Considerations, Appendix C and D.

Appendix D

METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WQS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS (WQS)[ii]	Notes
Overall use protection (all beneficial uses)	Narrative criteria for which quantifiable measurements can be made	1-4	Full: Stream condition typical of reference or appropriate regional control streams. Non-Attainment: Weight of evidence, based on the narrative criteria in 10 CSR 20-7.031(3), demonstrates the observed condition exceeds a numeric threshold necessary for the attainment of a beneficial use. *Color Example:* Color as measured by the Platinum-Cobalt visual method (SM 2120 B) in a water body is significantly higher (statistically) than a control water. *Objectionable Bottom Deposit Example:* The bottom covered by anthropogenic substances (e.g., sewage sludge, trash) exceeds the amount in reference or control streams by more than 20 percent. **Note:** Waters in mixing zones and unclassified waters that support aquatic life on an intermittent basis shall be subject to acute toxicity criteria for protection of aquatic life. Waters in the initial Zone of Dilution shall not be subject to acute toxicity criteria.	
Protection of Aquatic Life	Toxic Chemicals	1-4	Full: No more than one acute toxic event in three years (excluding natural die-offs of aquatic life). No more than one exceedance of acute or chronic criterion in three years for all toxins. Non-Attainment: Requirements for full attainment not met.	**Compliance with WQS Note**: Test result must be representative of water quality for the entire time period for which acute or chronic criteria apply. For ammonia, the chronic and acute exposure periods are 30 days and one hour, respectively. For all other toxics, the chronic and acute exposure periods are 96 hours and 24 hours, respectively. The Department will review all appropriate data, including hydrography, to ensure only representative data are used. Except on large rivers where storm water flows may persist at relatively unvarying levels for several days, grab samples

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BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS (WQS)[ii]	Notes
Protection of Aquatic Life (cont.)	Toxic Chemicals (cont.)	See above.	See above.	collected during storm water flows will not be used for assessing chronic toxicity criteria. **Compliance with WQS Note:** For toxic chemicals occurring in benthic sediment rather than water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations (PECs) proposed by MacDonald *et al.* (2000).[1] These PEC thresholds are as follows: (in mg/kg) 33 As; 4.98 Cd; 111 Cr; 149 Cu; 48.6 Ni; 128 Pb; 459 Zn; and (in µg/kg) 22,800 total PAHs; 676 total PCBs; 17.6 chlordane ; 31.3 Sum DDE ; 4.99 lindane (gamma-BHC) . Where multiple sediment contaminants exist, the PECQ shall not exceed 0.75. See Appendix D and Section II. D for more on the PECQ.
Protection of Aquatic Life	Biological: Aquatic Macro-invertebrates sampled following Department Protocol	3-4	<u>Full</u>: For seven or fewer samples, 75 percent of stream condition index scores must be ≥16. Samples achieving these scores are considered very similar to regional reference streams. For greater than seven samples or for other sampling and evaluation protocols, results must be statistically similar to representative reference or control stream. <u>Non-Attainment</u>: For seven or fewer samples, 75 percent of stream condition index scores must be ≤14. Samples achieving these scores are considered substantially different from regional reference streams. For more than seven samples or for other sampling and evaluation protocols, results must be statistically dissimilar to control or representative reference streams.	**Data Type Note:** DNR macroinvertebrate protocol will not be used for assessment in the Mississippi Alluvial Basin (Bootheel area) due to lack of reference streams for comparison. **Data Type Note:** See Section II.D for additional criteria used to assess biological data. **Compliance with WQS Note:** See Appendix D. For test streams significantly smaller than biocriteria reference (bioreference) streams where both bioreference streams and small candidate reference streams are used to assess the test stream's biological integrity, the data assessment should display and consider both bioreference streams and candidate reference streams.

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METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WQS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS (WQS)[ii]	Notes
Protection of Aquatic Life	Biological: MDC RAM Fish Community Protocol (Ozark Plateau only)	3-4	<u>Full:</u> For seven or fewer samples, 75 percent of fIBI scores must be ≥36. Samples achieving these scores are considered very similar to regional reference streams. For more than seven samples or for other sampling and evaluation protocols, results must be statistically similar to representative reference or control streams. <u>Suspected of Impairment</u>: Data inconclusive (Category 2B or 3B). For 1st and 2nd order streams, fIBI scores <29 <u>Non-Attainment:</u> 1st and 2nd order streams will not be assessed for non-attainment. When assessing 3rd to 5th order streams with seven or fewer samples, 75 percent of fIBI scores must be <36. Samples achieving these scores are considered substantially different from regional reference streams. For more than seven samples or for other sampling and evaluation protocols, results must be statistically dissimilar to control or representative reference streams.	**Data Type Note:** See Section II. D for additional criteria used to assess biological data. **Compliance with WQS Note:** MDC fIBI scores are from Doisy et al. (2008).[2] If habitat limitations (as measured by either the QCPH1 index or other appropriate methods) are judged to contribute to low fIBI scores and this is the only type of data available, the water body will be included in Category 4C, 2B, or 3B. If other types of data exist, the weight of evidence approach will be used as described in this LMD. **Compliance with WQS Note:** For determining influence of poor habitat on impaired samples, MDC RAM staff will be consulted. If, through this consultation, habitat is determined to be a significant probable cause for impairment, the water body will not be rated as impaired, but rather as suspected of impairment (Categories 2B or 3B). **Compliance with WQS Note:** See Appendix D. For test streams significantly smaller than bioreference streams where both bioreference streams and small candidate reference streams are used to assess the test stream's biological integrity, the data assessment should display and consider both biocriteria reference streams and candidate reference streams.
	Other Biological Data	3-4	<u>Full:</u> Results must be statistically similar to representative reference or control streams. <u>Non-Attainment:</u> Results must be statistically dissimilar to control or representative reference streams.	**Data Type Note:** See Section II. D for additional criteria used to assess biological data
	Toxicity testing using aquatic organisms (streams or lakes)	2	<u>Full</u>: No more than one test result of statistically significant deviation from controls in acute or chronic test in a three-year period. <u>Non-Attainment</u>: Requirements for full attainment not met.	

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METHODS FOR ASSESSING COMPLIANCE WITH WQS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WQS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS (WQS)[ii]	Notes
Human Health - Fish Consumption	Chemicals (tissue)	1-2	Full: Contaminant levels in fish tissue (fillets, tissue plugs, eggs) do not exceed guidelines. Non-Attainment: Requirements for full attainment not met.	**Compliance with WQS Note**: Fish tissue thresholds are chlordane[3] 0.1 mg/kg; mercury[4] 0.3 mg/kg; PCBs[5] 0.75 mg/kg; and lead[6] 0.3 mg/kg. Assessment of mercury will be based on samples solely from the following higher trophic level fish species: walleye, sauger, trout, black bass, white bass, striped bass, northern pike, flathead catfish and blue catfish.

[ii] **See section on Statistical Considerations and Appendix D.**

[1] MacDonald, D.D, Ingersoll, C. G., Berger, T. A. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contamination Toxicology. 39, 20-31.

[2] Doisy, K.E., C.F. Rabeni, M.D. Combes, and R.J. Sarver. 2008. Biological criteria for stream fish communities of Missouri. Final Report to the United States Environmental Protection Agency. Missouri Cooperative Fish and Wildlife Research Unit, Columbia, MO. 91.

[3] Crellin, J.R. 1989. *"New Trigger Levels for Chlordane in Fish-Revised Memo."* MO Dept of Health inter-office memorandum. June 16, 1989

[4] US EPA. 2001. Water quality criterion for protection of human health: methylmercury. EPA-823-R-01-001. http://www.epa.gov/waterscience/criteria/methylmercury/merctitl.pdf

[5] DHSS. 2006. *"Development of PCB Risk-based Fish Consumption Limit Tables."* MO Dept of Health and Senior Services Memorandum. August 30, 2006.

[6] World Health Organization. 1972. *"Evaluation of Certain Food Additives and the Contaminants Mercury, Lead and Cadmium."* WHO Technical Report Series No. 505, Sixteenth Report on the Joint FAO/WHO Expert Committee on Food Additives. Geneva. 33.

Appendix E

DESCRIPTION OF ANALYTICAL TOOLS USED FOR DETERMINING THE STATUS OF MISSOURI WATERS (11” X 14” FOLD OUT)

			Determining when waters are impaired			Determining when waters are no longer impaired			
Designated Use	**Analytes**	**Analytical Tool**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**[iii]	**Significance Level (α)**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**	**Significance Level (α)**	**Notes**
Narrative Criteria	Color	Hypothesis Test, two sample, one tailed t-Test	Null Hypothesis: No difference in color between test stream and control stream.	Reject Null Hypothesis if calculated “t” value exceeds tabular “t” value for test alpha	0.1	Same Hypothesis	Same Criterion	Same Significance Level	
	Objectionable bottom deposits	Hypothesis Test, two sample, one tailed t-Test	Null Hypothesis: Solids of anthropogenic origin cover <20 percent of stream bottom where velocity is <0.5 feet/second.	Reject Null Hypothesis if 60 percent Lower Confidence Limit (LCL) of mean percent fine sediment deposition (pfsd) in stream is greater than the sum of the pfsd in the control and 20 percent more of the stream bottom. [i.e., where pfsd is expressed as a decimal, test stream pfsd > (control stream pfsd + 0.20)]	0.4	Same Hypothesis	Same Criterion	Same Significance Level	**Criterion Note:** If data is non-normal a nonparametric test will be used as a comparison of medians. The 20 percent difference still applies. With current software, the Mann-Whitney test is used.

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Designated Use	**Analytes**	**Analytical Tool**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule[iii]**	**Significance Level (α)**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**	**Significance Level (α)**	**Notes**
Aquatic Life	Biological monitoring (Narrative)	DNR Invert protocol: sample size of 7 or less, 75 percent of samples must score 14 or lower	Using DNR Invert Protocol, Null Hypothesis: Frequency of full sustaining scores for test stream is the same as biocriteria reference streams	Reject Null Hypothesis if frequency of fully sustaining scores on test stream is significantly less than for biocriteria reference streams	N/A	Same Hypothesis	Same Criterion	Same Significance Level	
		RAM fIBI protocol: sample size of 7 or less, 75 percent of samples must score <36							
		DNR Invert protocol OR RAM fIBI protocol with sample sizes of 8 or more: Binomial Probability	A direct comparison of frequencies between test and biocriteria reference streams will be made.	Rate as impaired if the frequency of biocriteria reference streams with fully supporting biological scores is greater than five percent more than test stream.	0.1	Same Hypothesis	Same Criterion	Same Significance Level	**Criterion Note:** For inverts, the reference number will change depending on which EDU the stream is in (X percent -5 percent), for RAM samples the reference number will always be 70 (75 percent-5 percent).
		For other biological data an appropriate parametric or	Null Hypothesis:	Reject Null Hypothesis if metric scores for test stream are	0.1	Same Hypothesis	Same Criterion	Same Significance Level	

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Designated Use	**Analytes**	**Analytical Tool**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule[iii]**	**Significance Level (α)**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**	**Significance Level (α)**	**Notes**
Aquatic Life (cont.)	Biological monitoring (Narrative)	nonparametric test will be used	Community metric(s) in test stream is the same as in a reference stream or control stream.	significantly less than reference or control streams.					
			Other biological monitoring to be determined by type of data.	Dependent upon available information	Dependent upon available information	Same Hypothesis	Same Criterion	Same Significance Level	
	Toxic chemicals, water (Numeric)	Not applicable (N/A)	No more than one toxic event, toxicity test failure or exceedance of acute or chronic criterion in 3 years.	N/A	N/A	N/A	N/A	N/A	
	Toxic chemicals, sediment (Narrative)	Comparison of geometric mean to PEC value, or	Parameter geomean exceeds PEC, or	For metals, use 150 percent PEC threshold. The	N/A	Parameter geomean is equal to or less than PEC, or	For metals, use 150 percent of PEC threshold. The PECQ	N/A	**Compliance with Water Quality Standards Note:** In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need

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Designated Use	**Analytes**	**Analytical Tool**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**[iii]	**Significance Level (α)**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**	**Significance Level (α)**	**Notes**
Aquatic Life (cont.)		calculation of a PECQ value.	site PECQ is exceeded.	PECQ threshold value is 0.75.		site PECQ equaled or not exceeded.	threshold value is 0.75.		for further evaluation will be the Probable Effect Concentrations (PECs) proposed by MacDonald *et al.* (2000).[1] These PECs are as follows (in mg/kg): 33 As; 4.98 Cd; 111 Cr; 149 Cu; 48.6 Ni; 128 Pb; 459 Zn; and (in µg/kg) ; 22,800 total PAHs676 total PCBs; 17.6 chlordane; 31.3 Sum DDE; 4.99 lindane (gamma-BHC). Where multiple sediment contaminants exist, the PECQ shall not exceed 0.75. See Appendix D and Section II. D for more information on PECQs.
	Temperature, pH, total dissolved gases, oil and grease, dissolved oxygen (Numeric)	Binomial probability	Null Hypothesis: No more than 10 percent of samples exceed the water quality criterion.	Reject Null Hypothesis if the Type I error rate is less than 0.1.	N/A	Same Hypothesis	Same Criterion	N/A	Data collected will be treated as is and the binomial probability calculation will be used for assessment.
Human Health – Fish Consumption	Toxic chemicals, water (Numeric)	Hypothesis test: 1-sided confidence limit	Null Hypothesis: Contaminant levels in water do not exceed criterion.	Reject Null Hypothesis if the 60 percent LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject Null Hypothesis if the 60 percent UCL is greater than the criterion value.	Same Significance Level	
Human Health – Fish Consumption	Toxic chemicals, tissue (Narrative)	Four or more samples: Hypothesis test 1-sided confidence limit	Null Hypothesis: Contaminant levels in fillets or eggs do not exceed criterion.	Reject Null Hypothesis if the 60 percent LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60 percent UCL is greater than the criterion value.	Same Significance Level	

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Designated Use	**Analytes**	**Analytical Tool**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule[iii]**	**Significance Level (α)**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**	**Significance Level (α)**	**Notes**
Drinking Water Supply (Raw)	Toxic chemicals (Numeric)	Hypothesis test: 1-sided confidence limit	Null Hypothesis: Contaminant levels do not exceed criterion.	Reject Null Hypothesis if the 60 percent LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60 percent UCL is greater than the criterion value.	Same Significance Level	
	Non-toxic chemicals (Numeric)	Hypothesis test: 1-sided confidence limit	Null Hypothesis: Contaminant levels do not exceed criterion.	Reject Null Hypothesis: if the 60 percent LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60 percent UCL is greater than the criterion value.	Same Significance Level	
Drinking Water Supply (Finished)	Toxic chemicals	Stipulated by Safe Drinking Water Act	Stipulated by Safe Drinking Water Act	Stipulated by Safe Drinking Water Act	Stipulated by Safe Drinking Water Act	Same Hypothesis	Same Criterion	Same Significance Level	
Whole Body & Secondary Contact Recreation	Bacteria (Numeric)	Geometric mean	Null Hypothesis: Contaminant levels do not exceed criterion.	Reject Null Hypothesis: if the geometric mean is greater than the criterion value.	N/A	Same Hypothesis	Same Criterion	N/A	
Losing Streams	*E.coli*	Binomial probability	Null Hypothesis: No more than 10 percent of samples exceed the water quality criterion.	Reject Null Hypothesis if the Type I error rate is <0.1.	0.1	Same Hypothesis	Same Criterion	Same Significance Level	

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DESCRIPTION OF ANALYTICAL TOOLS USED FOR DETERMINING THE STATUS OF MISSOURI WATERS (11" X 14" FOLD OUT)

			Determining when waters are impaired			Determining when waters are no longer impaired			
Designated Use	**Analytes**	**Analytical Tool**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule[iii]**	**Significance Level (α)**	**Decision Rule/ Hypothesis**	**Criterion Used with the Decision Rule**	**Significance Level (α)**	**Notes**
Irrigation & Livestock Water	Toxic chemicals (Numeric)	Hypothesis test 1-Sided confidence limit	Null Hypothesis: Contaminant levels do not exceed criterion.	Reject Null Hypothesis if the 60 percent LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60 percent UCL is greater than the criterion value.	Same Significance Level	
Protection of Aquatic Life	Lake nutrients (Numeric – Site Specific)	Hypothesis test	Null hypothesis: Criteria are not exceeded.	Reject Null Hypothesis if 60 percent LCL value is greater than criterion value.	0.4	Same Hypothesis	Same Criterion	Same Significance Level	**Hypothesis Test Note:** State nutrient criteria require at least four samples per year taken near the outflow point of the lake (or reservoir) between May 1 and August 31 for at least four different, not necessarily consecutive, years.
	Lake nutrients (Numeric – Ecoregional)	See Appendix F	See Appendix F	See Appendix F	See Appendix F	Same Hypothesis	Same Criterion	Same Significance Level	See Appendix F for more information.

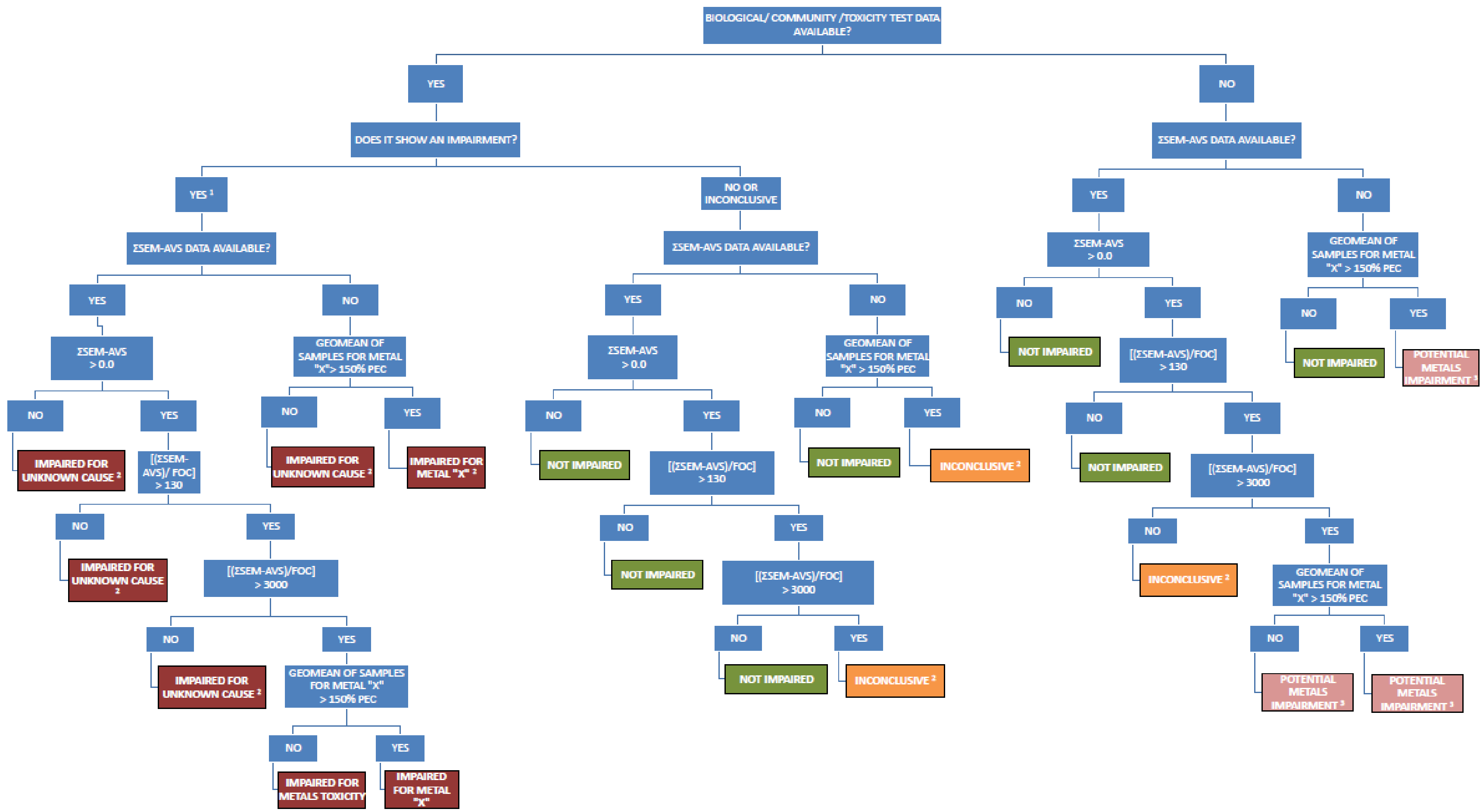
[iii] Where hypothesis testing is used for data sets with five samples or fewer (for media other than fish tissue), a 75 percent confidence interval around the appropriate central tendencies will be used to determine use attainment status. Use attainment will be determined as follows: (1) If the criterion value is above this interval (all values within the interval are in agreement with the criterion), rate as unimpaired; (2) If the criterion value falls within this interval, rate as unimpaired and place in Category 2B or 3B; (3) If the criterion value is below this interval (all values within the interval are not in agreement with the criterion), rate as impaired. For fish tissue, this procedure will be used with the following amendments: (1) it will apply only to sample sizes of less than four and, (2) a 50 percent confidence interval will be used in place of the 75 percent confidence interval.

[1] MacDonald, D.D, Ingersoll, C. G., Berger, T. A. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contamination Toxicology. 39, 20-31.

Appendix E

PICTORIAL REPRESENTATIONS OF THE WEIGHT OF EVIDENCE PROCEDURE FOR JUDGING TOXICITY OF SEDIMENT DUE TO METALS AND PAHS

Biological Weight of Evidence Decision Chart - Sediment Toxicity (Metals)



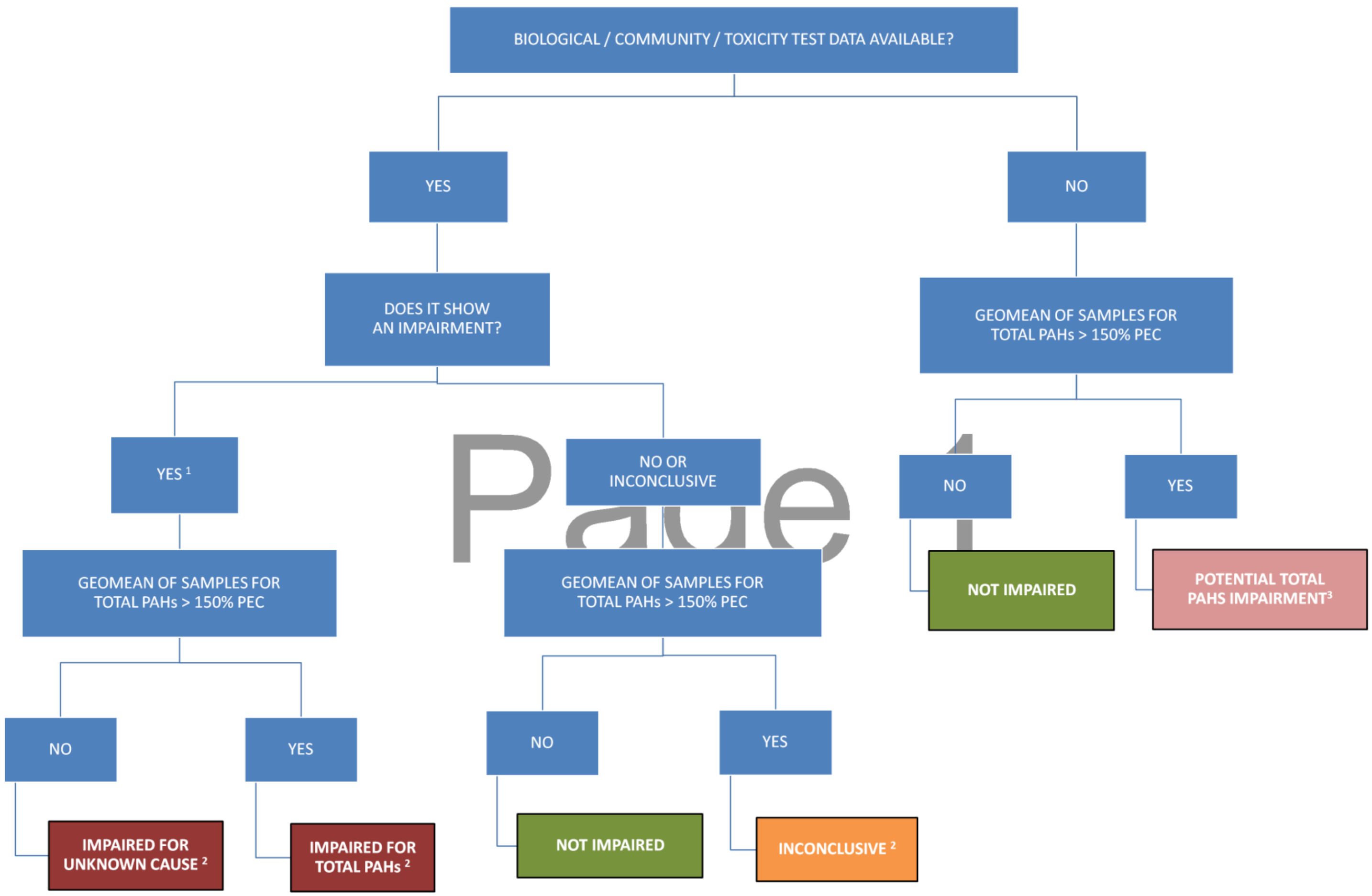
Notes:

1 - If there are Numeric WQS violations (unrelated to sediment) then follow LMD Procedure in LMD Appendix B. **Do Not Continue.**

2 - Note waterbody for further investigation related to metals or habitat issues.

3 - Note waterbody for Biological Sampling.

Biological Weight of Evidence Decision Chart - Sediment Toxicity (PAHs)



Notes:

1 - If there are Numeric WQS violations (unrelated to sediment) then follow LMD Procedure in LMD Appendix B. Do Not Continue.

2 - Note waterbody for further investigation.

3 - Note waterbody for Biological Sampling.

Appendix F

Missouri's Nutrient Criteria

Missouri Lakes and Reservoirs

For the purposes of Missouri's nutrient criteria and this document, all lakes and reservoirs are referred to as "lakes" [10 CSR 20-7.031(5)(N)1.A.]. Missouri's lakes are more appropriately classified as impoundments and have very different physical, chemical, and biological characteristics when compared to naturally-formed glacial or mountainous lakes found in other states. Many of Missouri's major lakes were constructed primarily for flood control, hydroelectric power, and water supply. The riverine habitats and species that existed before impoundment over time transitioned into the current state of aquatic life dominated by self-sustaining populations of sport and non-sport fishes. The numeric nutrient criteria and implementation methods proposed by the Department are structured to ensure the deleterious impacts of nutrient enrichment to Missouri's lakes are mitigated without adverse impacts to the health and vitality of the self-sustaining populations of aquatic life that live there.

Missouri's nutrient criteria apply to all lakes that are waters of the state and have an area of at least 10 acres during normal pool condition, except the natural lakes (oxbows) in the Big River Floodplain ecoregion [10 CSR 20-7.031(5)(N)2.]. The criteria apply to, and assessments will be conducted for, the entire water body as found in Missouri's WQS regulation. As noted in the *Rationale for Missouri Lake Nutrient Criteria* (DNR, 2017), the Department has structured Missouri's nutrient criteria as a decision framework that applies at an ecoregional basis. This decision framework integrates causal and response parameters into one WQS that accounts for uncertainty in linkages between causal and response parameters. The decision framework includes response impairment thresholds, nutrient screening thresholds, and response assessment endpoints. This framework appropriately integrates causal and response parameters and is based on the bioconfirmation guiding principles that EPA (2013) has suggested as an approach for developing nutrient criteria.

Numeric Criteria for Lakes [10 CSR 20-7.031(5)(N)]

Missouri's WQS contain response impairment threshold values for chlorophyll-a (Chl-a) and screening threshold values for total nitrogen (TN), total phosphorus (TP), and Chl-a, all of which vary by the dominant watershed ecoregion. Lakes are determined to be impaired if the geometric mean of samples taken between May and September in a calendar year exceeds the Chl-a response impairment threshold value more than once in three years' time. A duration of three or more years is necessary to account for natural variations in nutrient levels due to climatic variability (Jones and Knowlton, 2005). If a lake exceeds a screening threshold value, it will be designated as impaired if any of five response assessment endpoints also are identified in the same calendar year.

Lake Ecoregion	Chl-a Response Impairment Thresholds (µg/L)	Nutrient Screening Thresholds (µg/L)		
		TP	TN	Chl-a
Plains	30	49	843	18
Ozark Boarder	22	40	733	13
Ozark Highland	15	16	401	6

The five response assessment endpoints are:
- Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms
- Epilimnetic excursions from dissolved oxygen or pH criteria
- Cyanobacteria counts in excess of 100,000 cells/mL
- Observed shifts in aquatic diversity attributed to eutrophication
- Excessive levels of mineral turbidity that consistently limit algal productivity during the period of May 1 – September 30

All scientific references used for numeric nutrient criteria derivation are contained in the *Rationale for Missouri Lake Nutrient Criteria* (DNR, 2017) and supplemental materials maintained by the Department. The Department maintains a copy of these references and makes them available to the public for inspection and copying at no more than the actual cost of reproduction.

Narrative Criteria [10 CSR 20-7.031(4)]
Missouri’s WQS contain general (narrative) water quality criteria that are used to protect waters from nutrient enrichment caused by excessive nitrogen and/or phosphorous loading. Missouri’s general criteria protect waters from “unsightly or harmful bottom deposits” and “unsightly color or turbidity,” which are potential consequences of excess nutrients in freshwater systems. Narrative criteria do not provide numeric thresholds or concentrations above which impacts to designated uses are likely to occur. However, because the bioconfirmation approach integrates causal and response variables to ensure attainment of the aquatic habitat protection use, the proposed numeric nutrient criteria and screening thresholds serve as an enforceable interpretation of Missouri’s general criteria at 10 CSR 20-7.031(4). Additionally, implementation of the numeric nutrient criteria and screening thresholds also will ensure protection of downstream waters as required by 10 CSR 20-7.031(4)(E) and 40 CFR 131.10(b).

Site-Specific Numeric Criteria [10 CSR 20-7.031(5)(N)]
Missouri’s WQS also contain numeric nutrient criteria for specific lakes. Each of the lakes listed in Table N of the WQS have site-specific criteria for TN, TP, and Chl-a, based on the annual geometric mean of a minimum of three years of data and characteristics of the lake. Additional site-specific criteria may be developed to account for the unique characteristics of a water body.

Data Requirements for Assessment

In order to assess a lake against the numeric nutrient criteria in 10 CSR 20-7.031(5)(N), the following data requirements must be met:

1. At least four samples collected between May 1 and September 30 under representative conditions, collected near the dam or deepest part of the reservoir, and collected within a half meter of the surface;
2. Each sample must have been analyzed for at least Chl-a, TN, TP, and Secchi depth;
3. At least three years of samples (years do not have to be consecutive). Data older than seven years will not be considered, consistent with the Department's LMD;
4. Data collected under a QAPP.

If these requirements are not met, the lake will be placed into Category 3 of Missouri's Integrated Water Quality Report (i.e., Missouri's 305(b) Report) until further information can be collected. In the case of lakes that have some data, but not enough to make an assessment, these lakes will be prioritized for additional sampling. Lakes with limited data where water quality trends or field observations point to possible impairment will receive the highest priority.

Criteria for Assessment

Each lake will be evaluated against the appropriate ecoregional or site-specific criteria located in Tables L, M, and N of 10 CSR 20-7.031 (reproduced below).

Table L: Lake Ecoregion Chl-a Response Impairment Threshold Values (µg/L)

Lake Ecoregion	Chl-a Response Impairment Thresholds
Plains	30
Ozark Border	22
Ozark Highland	15

Table M: Lake Ecoregion Nutrient Screening Threshold Values (µg/L)

Lake Ecoregion	Nutrient Screening Thresholds		
	TP	TN	Chl-a
Plains	49	843	18
Ozark Border	40	733	13
Ozark Highland	16	401	6

Table N: Site-Specific Nutrient Criteria

Lake Ecoregion	Lake	County	Site-Specific Criteria (µg/L)		
			TP	TN	Chl-a
Plains	Bowling Green Lake	Pike	21	502	6.5

	Bowling Green Lake (old)	Pike	31	506	5
	Forest Lake	Adair	21	412	4.3
	Fox Valley Lake	Clark	17	581	6.3
	Hazel Creek Lake	Adair	27	616	6.9
	Lincoln Lake – Cuivre River State Park	Lincoln	16	413	4.3
	Marie, Lake	Mercer	14	444	3.6
	Nehai Tonkaia Lake	Chariton	15	418	2.7
	Viking, Lake	Daviess	25	509	7.8
	Waukomis Lake	Platte	25	553	11
	Weatherby Lake	Platte	16	363	5.1
Ozark Border	Goose Creek Lake	St Francois	12	383	3.2
	Wauwanoka, Lake	Jefferson	12	384	6.1
Ozark Highland	Clearwater Lake	Wayne-Reynolds	13	220	2.6
	Council Bluff Lake	Iron	7	229	2.1
	Crane Lake	Iron	9	240	2.6
	Fourche Lake	Ripley	9	236	2.1
	Loggers Lake	Shannon	9	200	2.6
	Lower Taum Sauk Lake	Reynolds	9	203	2.6
	Noblett Lake	Douglas	9	211	2
	St. Joe State Park Lakes	St Francois	9	253	2
	Sunnen Lake	Washington	9	274	2.6
	Table Rock Lake	Stone	9	253	2.6
	Terre du Lac Lakes	St Francois	9	284	1.7
	Timberline Lakes	St Francois	8	276	1.5

Assessment Methodology

1. Site-Specific Lake Nutrient Criteria
   Lakes with site-specific numeric nutrient criteria (see Table N of 10 CSR 20-7.031) will be assessed using the current listing methodology. Missouri has a state regulation, 10 CSR 20-7.050, which requires a methodology be created and followed for the development of an impaired waters list. Missouri develops and provides public notice of the methodology every two years concurrently with the 303(d) list. The methodology is approved by the Missouri CWC before the Department can use it for assessments. The Department currently assesses against the existing site-specific lake nutrient criteria in the water quality standards.

2. Ecoregional Lake Nutrient Criteria
   Lakes with ecoregional nutrient criteria (see Tables L and M of 10 CSR 20-7.031) will be assessed using the following:

   a. For lakes with ecoregional criteria, a yearly geometric mean for Chl-a, TN, and TP will be calculated for the period of record. The latest three years (do not have to be

consecutive) of data will be used for assessment. These data are collected by the SLAP and the LMVP.

b. If the geometric mean of Chl-a exceeds the response impairment threshold in more than one of the latest three years of available data, the lake will be placed into Category 5 of Missouri's Integrated Report (IR) and go on the 303(d) list for Chl-a. If only two years of data are available and the geometric mean of Chl-a exceeds the response impairment threshold in both years, the lake will be placed into Category 5 of Missouri's IR and go on the 303(d) list for Chl-a.

c. If the geometric mean of Chl-a, TN, or TP exceeds the nutrient screening threshold, then additional response assessment endpoints will be evaluated (see Assessment Methodology Section #3 "Additional Lake Response Assessment Endpoints" below). If data for any of the response assessment endpoints indicates impairment in the same year that Chl-a, TN, or TP exceeds the nutrient screening threshold, the lake will be placed into Category 5 of Missouri's IR. If sufficient data are not available to assess the response assessment endpoints or they do not show impairment, then the water will be placed into Category 3B or 2B, respectively (assuming other uses are attaining) and prioritized for additional monitoring and ongoing evaluation of response assessment endpoints (see Monitoring Efforts Section). If a lake that is sampled in the LMVP is placed in Category 3B or 2B, then it may be moved to the SLAP to ensure all nutrient screening threshold data needed to complete a full assessment are available. The Department is committed to providing the data needed to complete the full assessment.

d. If the geometric mean of Chl-a, TN, or TP does not exceed the nutrient screening threshold, the water will be placed into the appropriate IR category based on the attainment of the other uses.

e. The period of record for the lake will be reviewed for the purpose of determining long-term trends in water quality. If a lake is determined to be trending towards potential impairment, the lake will be further scrutinized and prioritized for additional monitoring.

3. <u>Additional Lake Response Assessment Endpoints</u>
For lakes where the geometric mean of Chl-a, TN, or TP exceeds the ecoregional nutrient screening thresholds, the additional response assessment endpoints listed below will be evaluated. Each of these endpoints is linked to the protection of the aquatic habitat designated use and will be used to assess compliance with the numeric nutrient criteria when screening values are exceeded. When one of these endpoints indicate a eutrophication impact in the same year as a nutrient screening threshold exceedance, the lake will be placed into Category 5 and on the 303(d) list.

Response assessment endpoints observed in lakes without sufficient data for Chl-a, TP, or TN will be prioritized highest for additional sampling of Chl-a, TP, and TN.

a. 10 CSR 20-7.031(5)(N)6.A. – Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms (i.e., fish kills)

- Following the Department's LMD, two or more fish kills within the last three years of available data will result in the water being placed into Category 5 as well as the 303(d) list.

- Fish kills as a result of nutrient enrichment (eutrophication) in a lake indicate that current water quality may not be protective of the aquatic habitat designated use. The Department maintains contact with the MDC on fish kills that occur throughout the state. MDC, as well as the Department's Environmental Emergency Response and Water Protection Program, receive notifications of observed fish kills. MDC investigates all reported fish kills and provides a summary report of the species, size, and number of fish and other aquatic organisms killed. These reports are provided shortly after the investigation. Annual fish kill reports are compiled and provided to the Department.

  One such example of a fish kill annual report is MDC's Missouri Pollution and Fish Kill Investigations 2017 (published April 2018). The Department will continue to request these data and annual reports from MDC. This document includes fish kill data and causes as well as describes the methods used by MDC to assess fish kills.

- The Department will review reports for information pertaining to the cause of death as well as the potential sources. Fish populations can have seemingly random small die-offs related to disease, virus, or other natural causes. The Department will focus on die-offs related to DO, temperature, pH, algal blooms, and the toxins associated with algal blooms. More than one fish kill within 10 years or one large (>100 fish and covering more than ten percent of the lake area) fish kill documented to be caused by dissolved oxygen excursions, pH, algal blooms, or the toxins associated with algal blooms will constitute evidence of impairment.

b. 10 CSR 20-7.031(5)(N)6.B. – Epilimnetic excursions from dissolved oxygen or pH criteria

In lakes, DO is produced by atmospheric reaeration and the photosynthetic activity of aquatic plants and consumed through respiration. DO production by aquatic plants (primarily phytoplankton in Missouri reservoirs) is limited to the euphotic zone where sufficient light exists to support photosynthesis. In some lakes, reaeration and photosynthesis may be sufficient to support high DO levels throughout the water column during periods of complete mixing. Missouri lakes however, do not stay completely mixed and thermally stratify during the summer. The duration, depth, and areal extent of stratification in any lake is a function of site-specific lake variables and environmental factors. During the stratified period, the epilimnion (surface water layer) receives oxygen from the atmosphere and is dominated by primary production from phytoplankton and other aquatic plants. In contrast, the hypolimnion (deep, cool water zone) is largely separated from the epilimnion (surface layer) and is dominated by respiratory processes that use organic matter derived from autochthonous (in-lake) and allochthonous (watershed) sources. The strong temperature gradient between the epilimnion and hypolimnion generally restrict gas and nutrient circulation and limits the movement of

phytoplankton between the layers. As a result, respiration in the hypolimnion creates hypoxic conditions during the stratification period.

Data collected by the MU demonstrates that hypoxic hypolimnetic conditions (absent of DO) consistently occur during the summer in Missouri lakes regardless of trophic condition. Further, anoxic hypolimnetic conditions have even been measured in Missouri's high-quality oligotrophic lakes. It is apparent from the science and available data that low hypolimnetic DO conditions are the result of natural processes and should be expected in all lakes across the state. Thermal stratification and resulting anoxic hypolimnia limit the area where some more sensitive fish species thrive to the epilimnion. Assessment of DO in the epilimnion of lakes will ensure the protection of aquatic life and aquatic habitat designated use and the maintenance of a robust aquatic community. Therefore, it would be inappropriate to apply the 5.0 milligrams per liter DO criterion throughout the entire water column.

DO and pH criterion will apply only to the epilimnion during thermal stratification. DO and pH criteria will apply throughout the water column outside of thermal stratification.

Excess nutrient input into lakes causes an increase in primary productivity of a lake. This increase in productivity comes with an increasing demand for DO through both the living and the decaying portions of aquatic life. Increased productivity also causes algal populations to have exponential growth and decay rates that can cause swings in DO concentrations. Sudden drops in DO concentrations or low levels of DO concentrations can cause fish kills.

Similar to DO, water column pH levels are linked to photosynthesis and impacted by thermal stratification. During periods of high photosynthesis, carbon dioxide (CO_2) is removed from the water column and pH increases. Conversely, when respiration and decomposition is high, CO_2 levels increase and pH decreases. As described above, the natural temperature gradients during the summer growing season create conditions whereby the epilimnion is dominated by primary production and the hypolimnion is dominated by respiration. Therefore, the pH levels will typically be higher in the epilimnion and lower in the hypolimnion. Because the nutrient criteria are focused on the biological response variable Chl-a, which is highest in the epilimnion in the summer, it is appropriate to limit pH assessments to the epilimnion.

Excessive algal production can cause the pH of the epilimnion to rise above 9.0 in some cases. When pH falls outside of this range due to algal blooms and their eventual decomposition, aquatic life which requires a stable range of pH conditions to survive can suffer. As mentioned for dissolved oxygen, assessment of pH in the epilimnion of lakes against WQS will ensure the protection of aquatic life and the aquatic habitat designated use, and the maintenance of a robust aquatic community.

- At the time of sample collection, DO, water temperature, and pH will be measured near the surface as well as via sonde probe throughout the depth of the epilimnion (water surface to the thermocline). The sonde probe continuously collects data for a short period of time as it is lowered through the water column. This data is currently collected by the SLAP.

- Following the LMD procedure for DO: If more than 10 percent of the measurements are below the 5.0 mg/L minimum to protect aquatic life, the binomial probability will be used for to determine whether the criterion has been exceeded.

- Following the LMD procedure for pH: If more than 10 percent of the measurements are outside the 6.5 to 9.0 range to protect aquatic life, the binomial probability will be used to determine whether the criterion has been exceeded.

c. 10 CSR 20-7.031(5)(N)6.C. – Cyanobacteria counts in excess of one hundred thousand (100,000) cells per milliliter (cells/mL)

Cell counts of cyanobacteria (blue-green algae) greater than 100,000 can be indicative of a harmful algal bloom (HAB) and the increased probability of algal toxins in the lake. Certain species of blue-green algae can produce toxins harmful to both aquatic life and terrestrial life (including humans and pets). *Microcystis* can produce microcystin (liver toxin) and anatoxin-a (neurotoxin). *Dolichospermum*, in addition to producing microcystin and anatoxin-a, also can produce cylindrospermopsin (liver toxin) and saxitoxin (nerve toxin). These toxins can cause adverse effects on aquatic life, as well as humans recreating on surface waters. The Oregon Health Authority has developed recreational guidelines for issuing public health advisories in relation to algal toxins (Oregon Health Authority, 2019[28]). EPA has developed Section 304(a) criteria for algal toxins[29], the values contained in the Oregon Health Authority document are also at the same level as the EPA 304(a) criteria. Direct measurement of cyanobacteria cell counts is limited and currently prohibitively expensive at large scales. Until this method becomes more widely adopted or technology improves to reduce the cost, the Department will collect data on algal toxin concentrations as a surrogate indicator for cyanobacteria counts. While these toxin levels are recommended for protection of recreational uses, the Department is using these toxin levels as an indication that the phytoplankton community has experienced a significant shift in biodiversity. In balanced and diverse aquatic communities, cyanobacteria species are present, but are not in the quantities necessary to produce elevated toxin levels. Elevated toxin levels indicate that the biodiversity of the phytoplankton community is no longer balanced. In combination with an excursion of the nutrient screening thresholds, toxin levels above the recommended criteria indicate nutrient eutrophication is impairing the aquatic community.

- Cyanobacteria counts greater than 100,000 cells/mL suggest the presence and impact of a HAB in the water body. HABs and the algal toxins they produce pose a threat to the aquatic habitat protection and recreational designated uses. This data may be collected by agencies or county governments and, when available, the Department will request and use this information. The cyanobacteria cell count is based on the threat of unacceptable levels of algal toxins, which are currently being collected by the SLAP and the LMVP.

[28] (https://www.sciencedirect.com/science/article/abs/pii/S0034425714002211
[29] https://www.epa.gov/sites/production/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf

- Any algal toxin values exceeding the following thresholds during the same year one of the nutrient screening levels is exceeded will constitute evidence of impairment.

Microcystin	8.0 µg/L
Cylindospermopsin	15.0 µg/L
Anatoxin-a	15.0 µg/L
Saxitoxin	8.0 µg/L

d. 10 CSR 20-7.031(5)(N)6.D. – Observed shifts in aquatic diversity attributed to eutrophication

The health of an ecosystem can be assessed by looking at different aspects, one of which is the food web or chain. Chemical measurements can be taken to assess the nutrients and chlorophyll (as a surrogate for algae). Relative abundances of fish at the various levels of the food chain can be surveyed to see if it is in balance. High nutrient inputs along with high levels of suspended solids can cause a decrease in the number of sight-feeding predators and an increase in the number of the prey that the predators are unable to catch. More numerous prey put a strain on the resources available, resulting in smaller prey and smaller, less numerous predators. This imbalance in the number and/or size of fish, or a shift to less sight-feeding fish in favor of bottom-feeding fish such as carp, due to eutrophication is a cause for concern.

As the state agency responsible for the protection and management of fish, forest, and wildlife resources, MDC regularly monitors populations of primary sport fishes (black bass, crappie, catfish) in major reservoirs (typically annually) to ensure the agency has appropriate regulations in place to manage these fish populations for today and into the future. These populations of piscivorous (i.e., fish eating) sport fish, and the many planktivorous (i.e., plankton eating) non-sport fish that are their prey, are self-sustaining in Missouri's major reservoirs. Correspondence with MDC Fisheries Division confirms the agency does not conduct supplemental stocking for primary sport fishes (i.e., apex predators), nor does the agency conduct supplemental stocking of non-sport fish lower down the food chain (MDC, 2018).

Although MDC does not stock the primary sport and non-sport fishes noted above, MDC does stock additional fish species to provide a "bonus" or "specialty" sport fishing opportunity. Species included in the bonus or specialty fishing opportunities include (but are not limited to) paddlefish, rainbow trout, brown trout, striped bass, hybrid striped bass, walleye, and muskellunge. Many of these fish species are non-native and would not be capable of reproducing or sustaining populations in Missouri lakes.

MDC uses various sampling techniques including electrofishing, netting, creel surveys, and angler surveys to collect information related to fish populations and angler satisfaction over time. These data help to inform MDC's regulations for the capture of fish within Missouri lakes to ensure self-sustaining populations of sport- and non-sport fishes. The Department, in consultation with MDC, will use these data to determine whether shifts in aquatic diversity attributed to eutrophication are occurring in a lake. These data are contained within MDC's Fisheries Information Network System (FINS)

and annual reports of fish stocking activities such as the "Fish Stocking for Public Fishing and Aquatic Resource Education." In support of this approach, the last eight calendar year reports (CY 2010 – 2017) generated by MDC and supporting data have been included with this submittal.

- The Department will request any available information on the potential biological shifts in fish or invertebrate communities related to eutrophication. This includes data from other agencies (such as the U.S. Fish and Wildlife Service) that monitor the populations of game fish.

- The MDC regularly monitors fish populations of primary sport fishes (black bass, crappie, catfish) in major reservoirs (typically annually) to ensure the agency has appropriate regulations in place to manage these fish populations for today and into the future. These populations of sport-fish, and the non-sportfish that are their prey, are self-sustaining in Missouri's major reservoirs.

- The MDC uses various sampling techniques including electrofishing, netting, creel surveys, and angler surveys to collect information related to fish populations and angler satisfaction over time. These data in consultation with MDC will be used to determine whether shifts in aquatic diversity attributed to eutrophication are occurring in a lake.

- The MDC produces annual fishery management reports for Missouri's major lakes and reservoirs that detail the health of the fishery and includes number of species, catch per unit effort, relative density of fish and measures of fish condition and population size structure. One such example of an annual fishery management report is the Stockton Reservoir 2017 Annual Lake Report (published March 2018). The data supporting MDC's annual fishery management reports can also be made available to the Department. MoDNR will request these annual reports and data from MDC.

e. 10 CSR 20-7.031(5)(N)6.E. – Excessive levels of mineral turbidity that consistently limit algal productivity during the period May 1 – September 30 (i.e., light limitations)

It is widely recognized that mineral turbidity reduces transparency and thereby limits algal production (Jones and Hubbart, 2011). Excessive mineral turbidity and reduced water column transparency can suppress Chl-a levels despite high levels of nutrients. Pronounced and extended turbidity events could have the effect of reducing Chl-a on an average annual basis but still allow for periodically high peaks or algal blooms after sedimentation of mineral turbidity and increased transparency. Under such conditions, waterbodies experiencing harmful algal blooms may go undetected when assessed as an average annual geomean. The intent of this response variable is to identify such waterbodies that might otherwise go unidentified as impaired.

There are several ways to determine light availability in a lake. Some examples include: Secchi depth, light attenuation and photosynthetically active radiation (PAR), Chl-a/TP ratios, and measurements for turbidity and suspended sediments. All these methods can provide additional information on the amount of light available in the epilimnion and how

deep it penetrates into the lake. These data will be used to determine whether the lake has excess sediment in relation to nutrients for eutrophication impacts to occur.

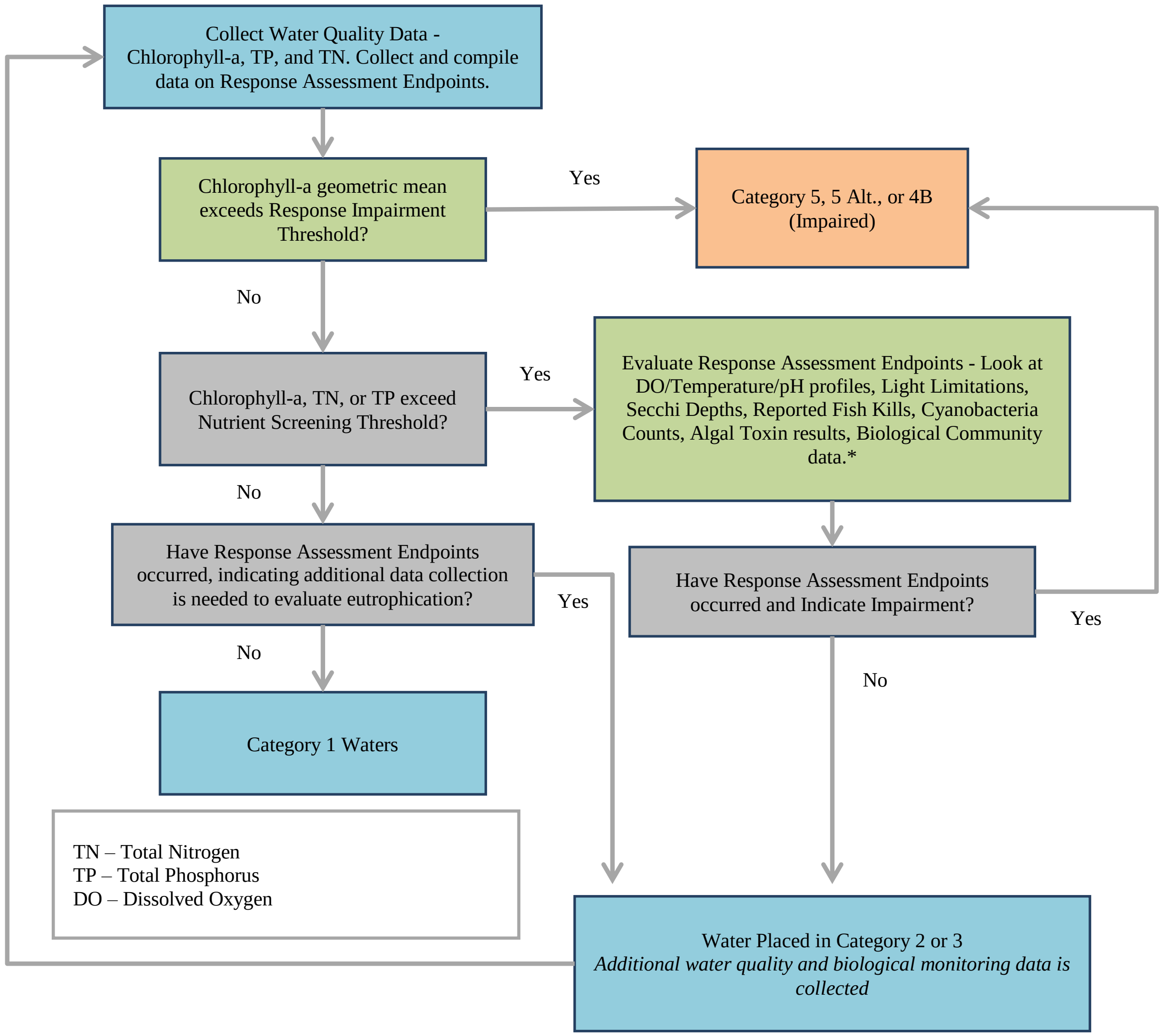
- Excessive mineral turbidity can reduce light penetration within the photic zone of lakes and limit algal productivity due to the lack of sunlight. Water clarity can be expressed through measurements such as Secchi depth, turbidity, and suspended solids. These data are collected by the SLAP and the LMVP under a cooperative agreement with the Department.

- Measured lake Secchi depths less than 0.6 meters in the Plains, 0.7 meters in the Ozark Border, and 0.9 meters in the Ozark Highlands is likely an indicator of excessive mineral turbidity that limits algal productivity in the water body (MDC 2012). This data is collected by the SLAP and the LMVP under a cooperative agreement with the Department. Yearly average Secchi depths below the applicable ecoregional value may constitute evidence of impairment. Additional analysis of average Chl-a/TP ratios will also be conducted before determining impairment status, as described below.

- The ratio of the average Chl-a to the average TP is an additional indicator of chlorophyll suppression in lakes due to mineral turbidity. A mean Chl-a/TP ratio less than or equal to 0.15 and a mean inorganic suspended solids value greater than or equal to 10 mg/L is suggestive of excessive mineral turbidity which limits algal productivity (Jones and Hubbart, 2011). Unless attributed to other physical factors, Chl-a/TP ratios at or below 0.15 and an ISS value greater than or equal to 10 mg/L as determined by yearly means will serve as an indicator of excessive mineral turbidity and constitute evidence of impairment. Assessment threshold values for Secchi depth, Chl-a/TP ratio, and ISS shall all be exceeded before determining a water is impaired.

- The Department will use data collected using a Li-Cor quantum sensor. Data collected with this equipment consists of light attenuation and photosynthetically active radiation (PAR). Until scientific literature on this new technology can be developed, the Department will rely on best professional judgment for when the data indicate light availability is limiting algal production to the point that if there were less or no limitation then the Chl-a values would be likely to exceed the criterion.

Figure 3. Missouri Ecoregional Numeric Nutrient Criteria Decision Framework based on the Bioconfirmation Approach.



Trend Analysis

The Department currently reports on physiographic region trends in Missouri's 305(b) Report. The latest version as well as past versions can be found on Missouri's 303(d) website: https://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm. These trends have been reported every cycle in the 305(b) Report since 1990. Trends for the physiographic regions are calculated based on at least 20 years of data. Trends are developed for Secchi depth, total phosphorus, total nitrogen, total chlorophyll, nonvolatile suspended solids, and volatile suspended solids.

The Department will evaluate individual lake trends for total phosphorus, total nitrogen, and Chl-a. Nutrients and chlorophyll can be seasonally variable, as well as wet and dry weather dependent. A minimum of ten years of data will be necessary to confidently evaluate water

quality trends in Missouri lakes due to significant annual variability and differing hydrologic conditions. Longer time periods are needed for more accurate predictions of impairment.

- When evaluating trends, confounding, or exogenous variables, such as natural phenomena (e.g., rainfall, flushing rate and temperature), must be controlled for.

- The trend must be statistically significant. This process involves standard statistical modeling, such as least squares regression or Locally Weighted Scatterplot Smoothing (LOWESS) analysis. To be considered statistically significant, the p value associated with the residuals trend analysis must be less than 0.05.

- Impairment decisions based on trend analysis should, at a minimum, demonstrate that the slope of the projected trend line is expected to exceed the chlorophyll criterion within five years and that there is evidence of anthropogenic nutrient enrichment. If the slope of the projected trend line is expected to exceed the chlorophyll criterion in greater than five years, the lake will be prioritized for additional monitoring and identified as a potential project for a 319 protection plan. A list of lakes that have increasing trends of nutrients or Chl-a will be added as an appendix to Missouri's future 305(b) Reports.

The Department will look for statistically significant trends in the DO/pH profile of lakes throughout the entire water column. Areas the Department will look at may include, but are limited to, mixing volumes, mixing depths, and severity of anoxia in the hypolimnion.

APPENDIX F – 2022 MISSOURI SECTION 303(D) LIST OF IMPAIRED WATERS

Missouri Department of Natural Resources
2022 Section 303(d) Listed Waters

Proposed List for EPA Approval. CWC approved on April 12, 2023

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
1	2012	2188	Antire Cr.	P	Y	1.9	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	St. Louis	07140102		M	
2	2018	2668	Ashley Cr.	P	Y	2.5	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Dent	11010008		H	2023
3	2006	7057	August A Busch Lake # 35	L3	Y	51.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009		L	
4	2018	7637	August A Busch Lake # 36	UL	Y	16.0	Acres	GEN	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009		L	
5	2010	7627	August A Busch Lake # 37	L3	Y	30.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009		L	
6	2020	7239	Austin Community Lake	L3	Y	21.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Texas	10290201	1	L	
7	2016	4083	Barker Creek trib.	C	Y	1.2	Miles	AQL	Oxygen, Dissolved (W)	Acid Mine Drainage	Henry	10290108		L	
8	2018	2693	Barn Hollow	C	Y	8.2	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Howell/ Texas	11010008		L	
9	2012	0752	Bass Cr.	C	Y	4.4	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		M	
10	2012	3240	Baynham Br.	P	Y	4.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070207	5	L	
11	**2022**	**0115**	**Bear Creek**	**C**	**N (7.9)**	**47.2**	**Miles**	**AQL**	**Chloride (W)**	**Kirksville WWTP**	**Adair**	**07110005**		L	
12	2014	3224	Beef Br.	P	Y	2.5	Miles	AQL	Cadmium (S)	Mill Tailings	Newton	11070207		M	
13	2014	3224	Beef Br.	P	Y	2.5	Miles	AQL	Lead (S)	Mill Tailings	Newton	11070207		M	
14	2014	3224	Beef Br.	P	Y	2.5	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207		M	
15	2014	7309	Bee Tree Lake	L3	Y	10.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Louis	07140102		L	
16	2006	7365	Belcher Branch Lake	L3	Y	42.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Buchanan	10240012		L	
17	2020	2179	Belew Cr.	P	Y	7.0	Miles	AQL	Oxygen, Dissolved (W)	Municipal Point Source Discharges, Source Unknown	Jefferson	07140104		L	
18	2020	7023	Belleview Lake	L1	Y	105.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lewis	07110003	1 2	H	2023

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
19	2016	7023	Belleview Lake	L1	Y	105.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Lewis	07110003	2	L	
20	2018	7186	Ben Branch Lake	L3	Y	37.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Osage	10300102		L	
21	2010	2916	Big Cr.	P	N (1.8)	34.1	Miles	AQL	Cadmium (S)	Glover smelter	Iron	08020202		M	
22	2010	1578	Big Piney River	P	Y	7.8	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source	Texas	10290202	2	M	
23	2006	2080	Big R.	P	N (52.8)	81.3	Miles	AQL	Cadmium (S)	Old Lead Belt tailings	St. Francois/ Jefferson	07140104		H	2022
24	2012	2080	Big R.	P	Y	81.3	Miles	AQL	Zinc (S)	Old Lead Belt tailings	St. Francois/ Jefferson	07140104		H	2022
25	2020	7185	Binder Lake	L3	Y	127.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cole	10300102	1	M	
26	2006	3184	Blackberry Cr.	C	N (3.5)	6.5	Miles	AQL	Chloride (W)	Asbury Power Plant	Jasper	11070207		M	
27	2008	3184	Blackberry Cr.	C	N (3.5)	6.5	Miles	AQL	Sulfate + Chloride (W)	Asbury Power Plant	Jasper	11070207		M	
28	2020	0112	Black Cr.	C	Y	21.8	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Shelby	07110005		H	2023
29	2006	3825	Black Creek	P	Y	5.6	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
30	2002	2769	Black R.	P	Y	47.1	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Butler	11010007	2	L	
31	2002	2784	Black R.	P	Y	39.0	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Wayne/ Butler	11010007	2	L	
32	2020	7189	Blind Pony Lake	L3	Y	96.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Saline	10300104	1	L	
33	2006	0417	Blue R.	P	Y	4.4	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
34	2006	0418	Blue R.	P	Y	9.4	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
35	2006	0419	Blue R.	P	Y	7.7	Miles	WBC A	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
36	2016	0417	Blue R.	P	Y	4.4	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
37	2012	1701	Bonhomme Cr.	C	Y	2.5	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	10300200		M	
38	2006	0750	Bonne Femme Cr.	P	Y	7.8	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		M	
39	2012	0753	Bonne Femme Cr.	C	Y	7.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	Boone	10300102		M	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
40	**2022**	**2034**	**Bourbeuse R.**	**P**	**N (21.4)**	**136.7**	**Miles**	**WBC A**	**Escherichia coli (W)**	**Nonpoint Source**	**Franklin**	**07140103**	**2**	M	
41	2002	2034	Bourbeuse R.	P	Y	136.7	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Phelps/ Franklin	07140103	2	L	
42	2012	1796	Brazeau Cr.	P	Y	10.8	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Perry	07140105		L	**5 Alt**
43	2002	1371	Brush Cr.	P	N (4.2)	4.7	Miles	AQL	Oxygen, Dissolved (W)	Humansville WWTP	Polk/ St. Clair	10290106		M	
44	2016	3986	Brush Creek	C	Y	5.4	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
45	**2022**	**3986**	**Brush Creek**	**C**	**Y**	**5.4**	**Miles**	**SCR**	**Escherichia coli (W)**	**Urban Runoff/ Storm Sewers**	**Jackson**	**10300101**		M	
46	2016	3986	Brush Creek	C	Y	5.4	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source	Jackson	10300101		L	
47	2020	7117	Buffalo Bill Lake	L3	Y	45.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1	L	
48	2016	7117	Buffalo Bill Lake	L3	Y	45.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	DeKalb	10280101		L	
49	2012	3273	Buffalo Cr.	P	Y	8.0	Miles	AQL	Fishes Bioassessments/ Unknown (W)	Source Unknown	Newton/ McDonald	11070208	3	L	
50	2008	3118	Buffalo Ditch	P	Y	17.3	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dunklin	08020204		M	
51	2006	1865	Burgher Br.	C	Y	1.5	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Phelps	07140102		H	2022
52	2018	3414	Burr Oak Cr.	C	Y	6.8	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
53	2018	3414	Burr Oak Cr.	C	Y	6.8	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
54	2020	3414	Burr Oak Cr.	C	Y	6.8	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Jackson	10300101		L	
55	2020	7229	Butler Lake	L1	Y	71.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Bates	10290102	1 2	L	
56	2020	7120	Cameron Lake #1	L1	Y	25.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1 2	L	
57	**2022**	**7121**	**Cameron Lake #2**	**L1**	**Y**	**31.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**DeKalb**	**10280101**	**1 2**	L	
58	2020	7384	Cameron Lake #4 (Grindstone Reservoir)	L1	Y	173.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1 2	L	
59	2006	3234	Capps Cr.	P	Y	5.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Barry/ Newton	11070207	5	L	
60	2016	3241	Carver Br.	P	Y	3.0	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Newton	11070207	5	L	
61	2010	2288	Castor R.	P	Y	7.5	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Bollinger	07140107		L	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
62	2020	7374	Catclaw Lake	L3	Y	42.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	
63	2008	1344	Cedar Cr.	P	N (10.9)	31.0	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Cedar	10290106	3	M	
64	2008	0737	Cedar Cr.	C	N (7.9)	37.4	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Boone	10300102	3	M	
65	2010	1357	Cedar Cr.	C	Y	16.2	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Dade/Cedar	10290106	3	L	
66	2008	1357	Cedar Cr.	C	Y	16.2	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dade/Cedar	10290106		M	
67	2010	1344	Cedar Cr.	P	N (10.9)	31.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Cedar	10290106		M	
68	2020	7199	Cedar Lake	L3	Y	21.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Boone	10300102	1	L	
69	2008	3210	Center Cr.	P	Y	21.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton/ Jasper	11070207	5	L	
70	2010	3214	Center Cr.	P	Y	4.9	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/ Newton	11070207	5	L	
71	2012	3203	Center Cr.	P	Y	26.8	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Jasper	11070207		L	
72	2012	3963	Chat Creek trib.	US	Y	0.9	Miles	GEN	Cadmium (W)	Baldwin Park Mine	Lawrence	11070207		M	
73	2012	3963	Chat Creek trib.	US	Y	0.9	Miles	GEN	Zinc (W)	Baldwin Park Mine	Lawrence	11070207		M	
74	2014	7634	Chaumiere Lake	L3	Y	3.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Clay	10300101		L	
75	2012	1781	Cinque Hommes Cr.	P	Y	17.1	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Perry	07140105		L	**5 Alt**
76	2016	1781	Cinque Hommes Cr.	P	N (15.4)	17.1	Miles	SCR	Escherichia coli (W)	Perryville SE WWTP, Nonpoint Source	Perry	07140105		L	**5 Alt**
77	**2022**	**7217**	**City Lake Harrisonville**	**L1**	**Y**	**28.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Cass**	**10290108**	**1 2**	L	
78	2018	1000	Clark Fk.	C	Y	6.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Cole	10300102		L	
79	2006	3238	Clear Cr.	P	Y	11.1	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence/ Newton	11070207	5	L	
80	2002	3239	Clear Cr.	C	Y	3.5	Miles	AQL	Nutrient/ Eutrophication Biol. Indicators (W)	Monett WWTP	Barry/ Lawrence	11070207	1	M	
81	2002	3239	Clear Cr.	C	Y	3.5	Miles	AQL	Oxygen, Dissolved (W)	Monett WWTP	Barry/ Lawrence	11070207		M	
82	2006	0935	Clear Fk.	P	N (3.1)	25.8	Miles	AQL	Oxygen, Dissolved (W)	Knob Noster WWTP	Johnson	10300104		M	

Row #	Year	WBID	Water body	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
83	2014	7326	Clearwater Lake	L2	Y	1635.0	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Reynolds/ Wayne	11010007	1	L	
84	2002	7326	Clearwater Lake	L2	Y	1635.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Reynolds/ Wayne	11010007		L	
85	2006	1706	Coldwater Cr.	C	Y	6.9	Miles	AQL	Oxygen, Dissolved (W)	Urban Runoff/ Storm Sewers	St. Louis	10300200		L	
86	2020	7378	Coot Lake	L3	Y	20.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	
87	2016	7378	Coot Lake	L3	Y	20.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10290108		L	
88	2016	7379	Cottontail Lake	L3	Y	22.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10290108		L	
89	2020	3962	Crackerneck Cr.	C	Y	6.0	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
90	**2022**	**3962**	**Crackerneck Cr.**	**C**	**Y**	**6.0**	**Miles**	**SCR**	**Escherichia coli (W)**	**Urban Runoff/ Storm Sewers**	**Jackson**	**10300101**		M	
91	2012	2382	Crane Cr.	P	Y	13.2	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Stone	11010002	3	L	
92	2016	7334	Crane Lake	L3	Y	109.0	Acres	AQL	Chlorophyll-a (W)	Source Unknown	Iron	08020202	1	L	
93	2016	7334	Crane Lake	L3	Y	109.0	Acres	AQL	Phosphorus, Total (W)	Source Unknown	Iron	08020202	1	L	
94	2012	2816	Craven Ditch	C	Y	11.6	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Butler	11010007		L	
95	2006	1703	Creve Coeur Cr.	C	Y	3.8	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	10300200		M	
96	2008	3961	Crooked Creek	C	Y	6.5	Miles	AQL	Cadmium (W)	Buick Lead Smelter	Iron/ Crawford	07140102		M	
97	2010	3961	Crooked Creek	C	Y	6.5	Miles	AQL	Copper (W)	Buick Lead Smelter	Iron/ Crawford	07140102		M	
98	2016	7135	Crowder St. Park Lake	L3	Y	18.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Grundy	10280102		L	
99	2020	0152	Cuivre R.	P	Y	30.0	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Lincoln/ St. Charles	07110008		H	2022
100	2006	2636	Current R.	P	Y	124.0	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Shannon/ Ripley	11010008		L	
101	2018	2662	Current R.	P	Y	18.8	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Dent/ Shannon	11010008		L	
102	2020	7647	Dairy Farm Lake # 1	L3	Y	14.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Boone	10300102	1	L	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
103	2018	0221	Dardenne Cr.	P	Y	16.5	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Charles	07110009		M	
104	2020	0222	Dardenne Cr.	C	Y	8.5	Miles	WBC B	Escherichia coli (W)	Urban Runoff and Nonpoint Source	St. Charles	07110009		L	
105	2006	0219	Dardenne Cr.	P1	Y	7.0	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source	St. Charles	07110009		M	
106	**2022**	**0222**	**Dardenne Cr.**	**C**	**Y**	**8.5**	**Miles**	**AQL**	**Sedimentation/ Siltation (W)**	**Nonpoint Source**	**St. Charles**	**07110009**		L	
107	2006	3826	Deer Creek	P	Y	1.6	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis/ St. Louis City	07140101		M	
108	**2022**	**4077**	**Deer Creek**	**C**	**Y**	**1.6**	**Miles**	**WBC A**	**Escherichia coli (W)**	**Source Unknown**	**St. Louis**	**07140101**		L	
109	2020	7015	Deer Ridge Community Lake	L3	Y	45.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lewis	07110002	1	L	
110	2002	7015	Deer Ridge Community Lake	L3	Y	45.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Lewis	07110002		L	
111	2006	3109	Ditch #36	P	Y	7.8	Miles	AQL	Oxygen, Dissolved (W)	Channelization, Nonpoint Source	Dunklin	08020204		M	
112	2006	3810	Douger Br.	C	Y	2.8	Miles	AQL	Lead (S)	Aurora Lead Mining District	Lawrence	11070207		M	
113	2006	3810	Douger Br.	C	Y	2.8	Miles	AQL	Zinc (S)	Aurora Lead Mining District	Lawrence	11070207		M	
114	**2022**	**7230**	**Drexel City Reservoir South**	**L1**	**Y**	**51.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Bates**	**10290102**	**1 2**	L	
115	2020	7228	Drexel Lake	L1	Y	28.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Bates	10290102	1 2	L	
116	2008	3189	Dry Fk.	C	Y	10.2	Miles	WBC A	Escherichia coli (W)	Rural NPS	Jasper	11070207	5	L	
117	2016	1792	Dry Fork	C	Y	9.0	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Perry	07140105		L	**5 Alt**
118	**2022**	**1792**	**Dry Fork**	**C**	**Y**	**9.0**	**Miles**	**SCR**	**Escherichia coli (W)**	**Nonpoint Source**	**Perry**	**07140105**		L	**5 Alt**
119	2016	3163	Dry Hollow	C	Y	0.5	Miles	SCR	Escherichia coli (W)	Source Unknown	Lawrence	11070207		M	
120	2016	3570	Dutro Carter Cr.	C	Y	0.5	Miles	SCR	Escherichia coli (W)	Source Unknown	Phelps	07140102		H	2023
121	2016	3570	Dutro Carter Cr.	C	Y	0.5	Miles	WBC B	Escherichia coli (W)	Source Unknown	Phelps	07140102		H	2023
122	2006	3569	Dutro Carter Cr.	P	N (0.5)	1.5	Miles	AQL	Oxygen, Dissolved (W)	Rolla SE WWTP	Phelps	07140102		M	
123	2016	3199	Duval Cr.	C	Y	7.0	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Jasper	11070207	5	L	
124	2006	2166	Eaton Br.	C	Y	1.2	Miles	AQL	Cadmium (S)	Leadwood tailings pond	St. Francois	07140104		H	2022
125	2006	2166	Eaton Br.	C	Y	1.2	Miles	AQL	Cadmium (W)	Leadwood tailings pond	St. Francois	07140104		H	2022

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126	2006	2166	Eaton Br.	C	Y	1.2	Miles	AQL	Lead (S)	Leadwood tailings pond	St. Francois	07140104		H	2022
127	2006	2166	Eaton Br.	C	Y	1.2	Miles	AQL	Zinc (S)	Leadwood tailings pond	St. Francois	07140104		H	2022
128	2006	2166	Eaton Br.	C	Y	1.2	Miles	AQL	Zinc (W)	Leadwood tailings pond	St. Francois	07140104		H	2022
129	2020	7026	Edina Reservoir	L1	Y	51.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Knox	07110003	1 2	L	
130	**2022**	**3107**	**E. Ditch #1**	**P**	**Y**	**22.0**	**Miles**	**AQL**	**Oxygen, Dissolved (W)**	**Source Unknown**	**New Madrid/ Dunklin**	**08020204**		M	
131	2020	7192	Edwin A Pape Lake	L1	Y	272.5	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lafayette	10300104	1 2	M	
132	2010	0372	E. Fk. Crooked R.	P	Y	19.9	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Ray	10300101		M	
133	2006	0457	E. Fk. Grand R.	P	Y	28.7	Miles	WBC A	Escherichia coli (W)	Rural NPS	Worth/ Gentry	10280101	2	H	2023
134	2020	0428	E. Fk. L. Blue R.	C	N (2.6)	3.7	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Jackson	10300101		L	
135	2008	0608	E. Fk. Locust Cr.	P	Y	16.7	Miles	WBC B	Escherichia coli (W)	Milan Lagoon and Nonpoint Source	Sullivan	10280103		M	
136	2008	0610	E. Fk. Locust Cr.	C	Y	15.7	Miles	WBC A	Escherichia coli (W)	Rural NPS	Sullivan	10280103		M	
137	2018	0608	E. Fk. Locust Cr.	P	Y	16.7	Miles	SCR	Escherichia coli (W)	Milan Lagoon and Nonpoint Source	Sullivan	10280103		M	
138	2018	1282	E. Fk. Tebo Cr.	C	Y	14.5	Miles	AQL	Ammonia, Total (W)	Municipal Point Source Discharges	Henry	10290108		L	
139	2006	1282	E. Fk. Tebo Cr.	C	N (10.4)	14.5	Miles	AQL	Oxygen, Dissolved (W)	Windsor SW WWTP	Henry	10290108		M	
140	2002	2593	Eleven Point R.	P	Y	22.7	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Oregon	11010011		L	
141	2006	2597	Eleven Point R.	P	Y	11.4	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Oregon	11010011		L	
142	2008	2601	Eleven Point R.	P	Y	22.3	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Oregon	11010011		L	
143	2002	0189	Elkhorn Cr.	C	N (17.6)	21.4	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Montgomery	07110008		L	
144	**2022**	**3246**	**Elk R.**	**P**	**N (2.2)**	**23.2**	**Miles**	**WBC A**	**Escherichia coli (W)**	**Nonpoint Source**	**McDonald**	**11070208**		L	
145	2020	7011	Ella Ewing Community Lake	L3	Y	12.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Scotland	07110002	1	L	
146	2006	1283	Elm Br.	C	Y	3.0	Miles	AQL	Oxygen, Dissolved (W)	Windsor SE WWTP	Henry	10290108		M	
147	2020	7146	Elmwood City Lake	L1	Y	197.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Sullivan	10280103	1 2	H	2023

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148	2018	4110	Engelholm Creek	C	Y	3.0	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
149	2018	4110	Engelholm Creek	C	Y	3.0	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
150	2012	1704	Fee Fee Cr. (new)	P	Y	1.5	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	10300200		M	
151	2012	7237	Fellows Lake	L1	Y	800.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Greene	10290106	2	L	
152	2016	3595	Fenton Cr.	P	Y	0.5	Miles	AQL	Chloride (W)	Source Unknown	St. Louis	07140102		M	
153	2012	3595	Fenton Cr.	P	Y	0.5	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140102		M	
154	2012	2186	Fishpot Cr.	P	Y	3.5	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140102		M	
155	2016	3220	Fivemile Cr.	P	N (4.9)	5.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070207	5	L	
156	2016	0864	Flat Cr.	P	Y	23.7	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Pettis/ Morgan	10300103		L	
157	2010	3938	Flat River trib.	US	Y	0.3	Miles	GEN	Zinc (W)	Elvins Chat Pile	St. Francois	07140104		M	
158	2020	3587	Fleck Cr.	C	Y	4.3	Miles	AQL	Sulfate + Chloride (W)	Coal Mining	Barton	10290104		L	
159	2010	7151	Forest Lake	L1	Y	580.0	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Adair	10280202	1 2	L	
160	2016	7151	Forest Lake	L1	Y	580.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Adair	10280202	2	L	
161	2016	3943	Foster Branch trib.	C	N (0.2)	2.0	Miles	AQL	Oxygen, Dissolved (W)	Ashland WWTF	Boone	10300102		M	
162	2018	7324	Fourche Lake	L3	Y	49.0	Acres	AQL	Chlorophyll-a (W)	Source Unknown	Ripley	11010009	1	L	
163	2018	7324	Fourche Lake	L3	Y	49.0	Acres	AQL	Nitrogen, Total (W)	Source Unknown	Ripley	11010009	1	L	
164	2006	0747	Fowler Cr.	C	Y	6.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Boone	10300102		M	
165	2010	7382	Foxboro Lake	L3	Y	22.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Franklin	07140103		L	
166	2008	0038	Fox R.	P	Y	42.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	Clark	07110001		M	
167	2014	7008	Fox Valley Lake	L3	Y	105.0	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Clark	07110001	1	L	
168	2014	7008	Fox Valley Lake	L3	Y	105.0	Acres	AQL	Nitrogen, Total (W)	Rural NPS	Clark	07110001	1	L	
169	2010	7008	Fox Valley Lake	L3	Y	105.0	Acres	AQL	Phosphorus, Total (W)	Rural NPS	Clark	07110001	1	L	

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170	2020	7328	Fredricktown City Lake	L1	Y	80.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Madison	08020202	1 2	L	
171	2002	7280	Frisco Lake	L3	Y	5.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Phelps	07140102		L	
172	2016	4061	Gailey Branch	C	Y	3.2	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Pike	07110007		M	
173	**2022**	**3373**	**Galloway Cr.**	**P**	**Y**	**3.2**	**Miles**	**WBC B**	**Escherichia coli (W)**	**Nonpoint Source**	**Greene**	**11010002**		L	
174	2012	1004	Gans Cr.	C	Y	5.5	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		M	
175	**2022**	**1455**	**Gasconade R.**	**P**	**N (8.9)**	**264.0**	**Miles**	**WBC A**	**Escherichia coli (W)**	**Nonpoint Source**	**Pulaski**	**10290203**	**2**	L	
176	2002	1455	Gasconade R.	P	Y	264.0	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Pulaski	10290203	2	L	
177	2020	7383	Gopher Lake	L3	Y	38.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	
178	2006	2184	Grand Glaize Cr.	C	Y	9.9	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140102		M	
179	2008	2184	Grand Glaize Cr.	C	Y	9.9	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140102		M	
180	2006	0593	Grand R.	P	Y	56.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Livingston/ Chariton	10280103	2	H	2023
181	**2022**	**0593**	**Grand R.**	**P**	**Y**	**56.0**	**Miles**	**SCR**	**Escherichia coli (W)**	**Nonpoint Source**	**Livingston/ Chariton**	**10280103**	**2**	H	2023
182	2006	1713	Gravois Creek	C	Y	10.7	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
183	2008	1712	Gravois Creek	P	Y	2.3	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis/ St. Louis City	07140101		M	
184	2016	4051	Gravois Creek trib.	C	Y	1.9	Miles	WBC B	Escherichia coli (W)	Municipal, Urbanized High Density Area, Urban Runoff/Storm Sewers	St. Louis	07140101		L	
185	2020	7161	Green City Lake	L1	Y	57.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Sullivan	10280202	1 2	L	
186	2020	7754	Greenly Farm Lake	L3	Y	17.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Knox	07110004	1	L	
187	2006	1009	Grindstone Cr.	C	Y	2.5	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		M	
188	2020	7124	Hamilton Lake	L1	Y	80.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Caldwell	10280101	1 2	L	
189	2020	7644	Happy Holler Lake	L3	Y	68.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Andrew	10240012	1	L	
190	2020	7386	Harrison County Lake	L1	Y	280.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Harrison	10280101	1 2	H	2022

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191	2014	7386	Harrison County Lake	L1	Y	280.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Harrison	10280101	2	L	
192	2020	7214	Harrisonville City Lake	L1	Y	419.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1 2	L	
193	2020	7207	Harry S Truman Reservoir	L2	Y	55600.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Benton	10290105	1 2	L	
194	2010	7152	Hazel Creek Lake	L1	Y	518.0	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Adair	10280201	1 2	L	
195	2018	7152	Hazel Creek Lake	L1	Y	518.0	Acres	AQL	Nitrogen, Total (W)	Nonpoint Source	Adair	10280201	1 2	L	
196	2020	7387	Hazel Hill Lake	L3	Y	62.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Johnson	10300104	1	L	
197	2016	2196	Headwater Div. Chan.	P	Y	20.3	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cape Girardeau	07140105	2	L	
198	2008	0848	Heaths Cr.	P	Y	21.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Pettis/ Cooper	10300103		M	
199	2020	7331	Hemitite Lake	L3	Y	215.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Francois	08020202	1	L	
200	2006	3226	Hickory Cr.	P	Y	4.9	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton	11070207	5	L	
201	2020	7190	Higginsville Reservoir (South)	L1	Y	147.1	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lafayette	10300104	1 2	L	
202	2012	1008	Hinkson Cr.	C	Y	18.8	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Boone	10300102		M	
203	2016	1007	Hinkson Cr.	P	Y	7.6	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Boone	10300102		M	
204	2016	7193	Holden City Lake	L1	Y	290.2	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Johnson	10300104	2	L	
205	2012	1011	Hominy Br.	C	Y	1.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	Boone	10300102		M	
206	2010	3169	Honey Cr.	P	Y	16.5	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
207	2010	3170	Honey Cr.	C	Y	2.7	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
208	2018	1251	Honey Cr.	C	Y	8.5	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Henry	10290108		L	
209	2010	1348	Horse Cr.	P	Y	27.7	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Vernon/ Cedar	10290106	3	L	
210	2008	1348	Horse Cr.	P	Y	27.7	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon/ Cedar	10290106		M	
211	2002	7388	Hough Park Lake	L3	Y	10.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cole	10300102		L	
212	2012	7029	Hunnewell Lake	L3	Y	228.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Shelby	07110004		L	

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213	2010	0420	Indian Cr.	C	Y	3.4	Miles	AQL	Chloride (W)	Road/Bridge Runoff, Non-construction	Jackson	10300101		M	
214	2002	0420	Indian Cr.	C	Y	3.4	Miles	WBC A	Escherichia coli (W)	Leawood, KS WWTP	Jackson	10300101		M	
215	2008	7389	Indian Creek Community Lake	L3	Y	199.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Livingston	10280101		L	
216	2020	7288	Indian Lake	L3	Y	279.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Crawford	07140103	1	L	
217	**2022**	**7288**	**Indian Lake**	**L3**	**Y**	**279.0**	**Acres**	**HHP**	**Mercury in Fish Tissue (W)**	**Atmospheric Deposition - Toxics**	**Crawford**	**07140103**		L	
218	2020	7391	Jackrabbit Lake	L3	Y	28.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	
219	2014	3223	Jacobs Br.	P	Y	1.6	Miles	AQL	Cadmium (S)	Tri-State Mining District	Newton	11070207		M	
220	2014	3223	Jacobs Br.	P	Y	1.6	Miles	AQL	Cadmium (W)	Tri-State Mining District	Newton	11070207		M	
221	2014	3223	Jacobs Br.	P	Y	1.6	Miles	AQL	Lead (S)	Tri-State Mining District	Newton	11070207		M	
222	2014	3223	Jacobs Br.	P	Y	1.6	Miles	AQL	Zinc (S)	Tri-State Mining District	Newton	11070207		M	
223	2012	3223	Jacobs Br.	P	Y	1.6	Miles	AQL	Zinc (W)	Tri-State Mining District	Newton	11070207		M	
224	2020	7104	Jamesport City Lake	L1	Y	16.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Daviess	10280101	1 2	L	
225	2020	7105	Jamesport Community Lake	L1	Y	27.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Daviess	10280101	1 2	L	
226	2020	2365	James R.	P	Y	39.0	Miles	WBC A	Escherichia coli (W)	Source Unknown	Greene	11010002	2	L	
227	2012	3207	Jenkins Cr.	P	Y	2.8	Miles	WBC A	Escherichia coli (W)	Rural NPS	Jasper	11070207	5	L	
228	2014	3208	Jenkins Cr.	C	Y	4.8	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton/ Jasper	11070207	5	L	
229	2012	3205	Jones Cr.	P	Y	7.5	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton/ Jasper	11070207	5	L	
230	2016	5006	Joplin Creek	C	Y	3.9	Miles	AQL	Cadmium (W)	Mill Tailings	Jasper	11070207		L	
231	2018	5006	Joplin Creek	C	Y	3.9	Miles	AQL	Zinc (W)	Mill Tailings	Jasper	11070207		L	
232	2014	3374	Jordan Cr.	P	Y	3.8	Miles	AQL	Polycyclic Aromatic Hydrocarbons-PAHs (S)	Urban NPS	Greene	11010002		L	
233	2020	7471	Jo Shelby Lake	L3	Y	30.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Linn	10280103	1	L	

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234	2012	3592	Keifer Creek	P	Y	1.2	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140102		L	
235	2012	3592	Keifer Creek	P	Y	1.2	Miles	WBC A	Escherichia coli (W)	Rural NPS	St. Louis	07140102		M	
236	**2022**	**7113**	**King City Old Reservoir**	**L1**	**Y**	**12.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Gentry**	**10280101**	**1 2**	L	
237	2020	7112	King Lake	L3	Y	204.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1 2	L	
238	2016	7657	Knox Village Lake	L3	Y	3.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101		L	
239	2016	2171	Koen Cr.	C	Y	1.0	Miles	AQL	Lead (S)	Mine Tailings	St. Francois	07140104		H	2022
240	2020	7056	Kraut Run Lake	L3	Y	164.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Charles	07110009	1	L	
241	2010	7297	Lac Capri	L3	Y	106.0	Acres	AQL	Nitrogen, Total (W)	Rural, Residential Areas	St. Francois	07140104	1 6	L	
242	2020	7605	Lac Carmel	L3	Y	55.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Francois	07140104	1	L	
243	**2022**	**7605**	**Lac Carmel**	**L3**	**Y**	**55.0**	**Acres**	**AQL**	**Nitrogen, Total (W)**	**Nonpoint Source**	**St. Francois**	**07140104**	**1**	L	
244	2020	7614	Lac Marseilles	L3	Y	48.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Francois	07140104	1	L	
245	**2022**	**7614**	**Lac Marseilles**	**L3**	**Y**	**48.0**	**Acres**	**AQL**	**Nitrogen, Total (W)**	**Nonpoint Source**	**St. Francois**	**07140104**	**1**	L	
246	2016	7659	Lake Boutin	L3	Y	20.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cape Girardeau	07140105		L	
247	2002	7469	Lake Buteo	L3	Y	7.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Johnson	10300104		L	
248	2020	7311	Lake Girardeau	L3	Y	144.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cape Girardeau	07140107	1	L	
249	2020	7332	Lake Killarney	L3	Y	61.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Iron	08020202	1	L	
250	**2022**	**7216**	**Lake Luna**	**L3**	**Y**	**23.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Cass**	**10290108**	**1**	L	
251	2020	7403	Lake Nell	L3	Y	26.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	
252	2020	7205	Lake of the Ozarks	L2	Y	59520.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Camden	10290109	1	L	
253	2002	7436	Lake of the Woods	L3	Y	3.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Boone	10300102		L	
254	2008	7629	Lake of the Woods	L3	Y	7.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101		L	
255	2016	7132	Lake Paho	L3	Y	273.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Mercer	10280102		L	
256	2014	7055	Lake Sainte Louise	L3	Y	71.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009		L	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
257	2020	7312	Lake Springfield	L3	Y	293.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Greene	11010002	1	L	
258	2020	7054	Lake St. Louis	L3	Y	444.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Charles	07110009	1	L	
259	**2022**	**7304**	**Lake Timberline**	**L3**	**Y**	**39.0**	**Acres**	**AQL**	**Nitrogen, Total (W)**	**Nonpoint Source**	**St. Francois**	**07140104**	**1**	L	
260	2016	7035	Lake Tom Sawyer	L3	Y	4.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Monroe	07110006		L	
261	2020	7341	Lake Tywappity	L3	Y	43.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Scott	08020204	1	L	
262	2020	7336	Lake Wappapello	L2	Y	7827.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Wayne	08020202	1	L	
263	**2022**	**7258**	**Lake Wauwanoka**	**L3**	**Y**	**93.0**	**Acres**	**AQL**	**Nitrogen, Total (W)**	**Nonpoint Source**	**Jefferson**	**07140101**	**1**	L	
264	2020	7212	Lake Winnebago	L3	Y	272.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1	L	
265	2010	7212	Lake Winnebago	L3	Y	272.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cass	10290108		L	
266	2006	0847	Lamine R.	P	Y	64.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Morgan/ Cooper	10300103		H	2023
267	2006	3105	Lateral #2 Main Ditch	P	Y	11.5	Miles	AQL	Oxygen, Dissolved (W)	Channelization, Municipal PS, NPS	Stoddard	08020204		M	
268	**2022**	**7082**	**Lawson City Lake**	**L1**	**Y**	**25.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Ray**	**10300101**	**1 2**	L	
269	2014	1529	L. Beaver Cr.	C	Y	3.5	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Phelps	10290203		M	
270	2012	0422	L. Blue R.	P	Y	35.1	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
271	2018	0422	L. Blue R.	P	Y	35.1	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
272	2012	1003	L. Bonne Femme Cr.	P	Y	9.0	Miles	WBC B	Escherichia coli (W)	Source Unknown	Boone	10300102		M	
273	2006	1863	L. Dry Fk.	P	N (1)	5.2	Miles	AQL	Oxygen, Dissolved (W)	Rolla SE WWTP	Phelps	07140102		M	
274	2006	1864	L. Dry Fk.	C	N (0.6)	4.7	Miles	AQL	Oxygen, Dissolved (W)	Rolla SE WWTP	Phelps	07140102		M	
275	2008	1864	L. Dry Fk.	C	Y	4.7	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Phelps	07140102		M	
276	2006	1325	L. Dry Wood Cr.	P	Y	20.5	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon	10290104		H	2023
277	2010	1326	L. Dry Wood Cr.	C	Y	15.6	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Barton/ Vernon	10290104		H	2023
278	2012	3137	Lee Rowe Ditch	C	Y	6.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Mississippi	08020201		M	
279	2018	7346	Lewis Lake	L3	Y	6.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Stoddard	08020204		L	

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280	2002	7020	Lewistown Lake	L1	Y	35.0	Acres	DWS	Atrazine (W)	Rural NPS	Lewis	07110002	2	M	
281	2020	7111	Limpp Community State Lake	L3	Y	27.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Gentry	10240012	1	L	
282	2012	3575	Line Cr.	C	Y	7.0	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Platte	10240011		M	
283	2018	4107	Little Blue River tributary	C	Y	5.5	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
284	2020	7180	Little Dixie Lake	L3	Y	199.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Callaway	10300102	1	L	
285	2014	2854	Little Saint Francis River	P	Y	17.9	Miles	AQL	Lead (S)	Catherine Lead Mine, pos. Mine La Motte	St. Francois/ Madison	08020202	2	M	
286	**2022**	**1438**	**L. Lindley Cr.**	**C**	**N (0.3)**	**3.7**	**Miles**	**AQL**	**Oxygen, Dissolved (W)**	**Source Unknown**	**Dallas**	**10290107**		L	
287	2006	0606	Locust Cr.	P	N (37.7)	91.7	Miles	WBC B	Escherichia coli (W)	Rural NPS	Putnam/ Sullivan	10280103	2	H	2023
288	2006	0696	Long Branch Cr.	C	N (1.8)	14.8	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source	Macon	10280203		M	
289	2002	7097	Longview Lake	L2	Y	953.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101		L	
290	2008	3652	L. Osage R.	C	Y	23.6	Miles	WBC B	Escherichia coli (W)	Rural NPS	Vernon	10290103		M	
291	**2022**	**7325**	**Lower Taum Sauk Lake**	**L3**	**Y**	**200.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Reynolds**	**11010007**	**1**	L	
292	**2022**	**7325**	**Lower Taum Sauk Lake**	**L3**	**Y**	**200.0**	**Acres**	**AQL**	**Nitrogen, Total (W)**	**Nonpoint Source**	**Reynolds**	**11010007**	**1**	L	
293	**2022**	**7325**	**Lower Taum Sauk Lake**	**L3**	**Y**	**200.0**	**Acres**	**AQL**	**Phosphorus, Total (W)**	**Nonpoint Source**	**Reynolds**	**11010007**	**1**	L	
294	**2022**	**7287**	**L. Prairie Comm. Lake**	**L3**	**Y**	**95.0**	**Acres**	**HHP**	**Mercury in Fish Tissue (W)**	**Atmospheric Deposition - Toxics**	**Phelps**	**07140103**		L	
295	2020	7168	Macon Lake	L3	Y	189.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Macon	10280203	1 2	L	
296	2012	3839	Maline Creek	C	Y	0.5	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis City	07140101		M	
297	**2022**	**7198**	**Manito Lake**	**L3**	**Y**	**77.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Moniteau**	**10300103**	**1**	L	
298	2016	7398	Maple Leaf Lake	L3	Y	127.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Lafayette	10300104		L	
299	2002	7033	Mark Twain Lake	L2	Y	18132.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ralls	07110005	2	L	
300	2018	4109	Martigney Creek	C	Y	1.6	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	

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301	2018	4109	Martigney Creek	C	Y	1.6	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
302	**2022**	**3596**	**Mattese Creek**	**P**	**Y**	**1.1**	**Miles**	**AQL**	**Chloride (W)**	**Urban Runoff/ Storm Sewers**	**St. Louis**	**07140102**		L	
303	**2022**	**3955**	**Mattese Creek**	**C**	**Y**	**6.7**	**Miles**	**AQL**	**Chloride (W)**	**Urban Runoff/ Storm Sewers**	**St. Louis**	**07140102**		L	
304	2014	3596	Mattese Creek	P	Y	1.1	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140102		M	
305	**2022**	**3955**	**Mattese Creek**	**C**	**Y**	**6.7**	**Miles**	**WBC B**	**Escherichia coli (W)**	**Urban Runoff/ Storm Sewers**	**St. Louis**	**07140102**		M	
306	2016	1786	McClanahan Cr.	C	Y	6.7	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Perry	07140105		L	**5 Alt**
307	2020	7013	Memphis Reservoir	L1	Y	41.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Scotland	07110002	1 2	L	
308	2010	0123	M. Fk. Salt R.	C	N (11.4)	25.4	Miles	AQL	Oxygen, Dissolved (W)	Macon WWTP	Macon	07110006		M	
309	2008	1299	Miami Cr.	P	Y	19.6	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Bates	10290102		M	
310	2006	0468	Middle Fk. Grand R.	P	Y	27.5	Miles	WBC A	Escherichia coli (W)	Rural NPS	Worth/ Gentry	10280101		H	2023
311	**2022**	**0468**	**Middle Fk. Grand R.**	**P**	**Y**	**27.5**	**Miles**	**SCR**	**Escherichia coli (W)**	**Rural NPS**	**Worth/ Gentry**	**10280101**		H	2023
312	2010	3262	Middle Indian Cr.	C	Y	3.5	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Newton	11070208	3	M	
313	2010	3263	Middle Indian Cr.	P	Y	2.2	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Newton	11070208	3	M	
314	2020	7144	Milan Lake North	L1	Y	13.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Sullivan	10280103	1 2	L	
315	2016	4066	Mill Creek	C	Y	3.4	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		M	
316	2016	4066	Mill Creek	C	Y	3.4	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		M	
317	2016	4066	Mill Creek	C	Y	3.4	Miles	AQL	Oxygen, Dissolved (W)	Urban Runoff/Storm Sewers	Jackson	10300101		M	
318	2010	0226	Missouri R.	P	Y	184.5	Miles	WBC B	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	Atchison/ Jackson	10240011	2	L	

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319	2012	0356	Missouri R.	P	Y	129.0	Miles	WBC B	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	Jackson/ Chariton	10300101	2	L	
320	2020	7031	Monroe City Lake	L1	Y	94.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Ralls	07110007	1 2	L	
321	2014	7031	Monroe City Lake	L1	Y	94.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ralls	07110007	2	L	
322	2020	7034	Monroe Lake B	L1	Y	60.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Monroe	07110007	1 2	L	
323	2016	7301	Monsanto Lake	L3	Y	18.0	Acres	AQL	Nitrogen, Total (W)	Nonpoint Source	St. Francois	07140104	1	L	
324	2020	7208	Montrose Lake	L3	Y	1444.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Henry	10290108	1	L	
325	2020	7402	Mozingo Lake	L1	Y	998.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Nodaway	10240013	1 2	L	
326	2010	7402	Mozingo Lake	L1	Y	998.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Nodaway	10240013	2	L	
327	2018	0853	Muddy Cr.	P	Y	62.2	Miles	WBC B	Escherichia coli (W)	Rural NPS	Pettis	10300103		M	
328	2010	7109	New City Lake	L3	Y	78.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Harrison	10280101		L	
329	2020	7136	New Marceline City Lake	L1	Y	160.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Chariton	10280103	1 2	M	
330	2016	0158	N. Fk. Cuivre R.	P	Y	25.1	Miles	WBC A	Escherichia coli (W)	Rural NPS	Pike/Lincoln	07110008		H	2022
331	2018	0110	N. Fk. Salt R.	P	Y	84.9	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Shelby/ Monroe	07110005	2	L	
332	2008	3186	N. Fk. Spring R.	P	Y	17.4	Miles	WBC B	Escherichia coli (W)	Rural NPS	Jasper	11070207	5	L	
333	2008	3188	N. Fk. Spring R.	C	Y	55.9	Miles	WBC B	Escherichia coli (W)	Rural NPS	Dade/Jasper	11070207	5	L	
334	2006	3188	N. Fk. Spring R.	C	Y	55.9	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source	Dade/Jasper	11070207		M	
335	2012	3260	N. Indian Cr.	P	Y	5.2	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Newton	11070208	3	M	
336	2014	0227	Nishnabotna R.	P	Y	10.2	Miles	WBC B	Escherichia coli (W)	Rural NPS	Atchison	10240004	2	M	
337	2018	0227	Nishnabotna R.	P	Y	10.2	Miles	SCR	Escherichia coli (W)	Rural NPS	Atchison	10240004	2	M	
338	2002	7316	Noblett Lake	L3	Y	26.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Douglas	11010006		L	
339	2014	7316	Noblett Lake	L3	Y	26.0	Acres	AQL	Phosphorus, Total (W)	Nonpoint Source	Douglas	11010006	1	L	
340	2010	0550	No Cr.	P	Y	28.7	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Grundy/ Livingston	10280102		M	

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341	2020	7076	Nodaway Lake	L3	Y	73.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Nodaway	10240013	1	L	
342	2016	7317	Norfork Lake	L2	Y	1000.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ozark	11010006		L	
343	2014	3811	North Branch Wilsons Cr.	P	Y	3.8	Miles	AQL	Zinc (S)	Urban NPS	Greene	11010002		M	
344	2020	7218	North Lake	L3	Y	38.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1	L	
345	**2022**	**7094**	**Odessa Lake (Old)**	**L1**	**Y**	**22.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Lafayette**	**10300101**	**1 2**	L	
346	2014	7003	Old Lake	L1	Y	28.0	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Pike	07110004	1 2	L	
347	2012	7003	Old Lake	L1	Y	28.0	Acres	AQL	Nitrogen, Total (W)	Rural NPS	Pike	07110004	1 2	L	
348	2012	7003	Old Lake	L1	Y	28.0	Acres	AQL	Phosphorus, Total (W)	Rural NPS	Pike	07110004	1 2	L	
349	2016	1794	Omete Creek	C	Y	5.7	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Perry	07140105		L	**5 Alt**
350	2018	3190	Opossum Cr.	C	Y	6.4	Miles	WBC B	Escherichia coli (W)	Rural NPS	Jasper	11070207	5	L	
351	2016	1293	Osage R.	P	Y	50.7	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Vernon/ St. Clair	10290105		H	2022
352	2006	1373	Panther Cr.	C	Y	9.7	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Polk/ St. Clair	10290106		M	
353	2020	7241	Peaceful Valley Lake	L3	Y	158.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Gasconade	10290203	1	L	
354	2008	2373	Pearson Cr.	P	Y	8.0	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Greene	11010002	3	L	
355	2006	2373	Pearson Cr.	P	Y	8.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Greene	11010002		L	
356	2016	0099	Peno Cr.	C	Y	14.4	Miles	AQL	Oxygen, Dissolved (W)	Northeast Correctional Center WWTP	Pike	07110007		M	
357	2020	7047	Perry City Lake	L1	Y	18.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Ralls	07110007	1 2	L	
358	2020	7273	Perry County Community Lake	L3	Y	89.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Perry	07140105	1	L	
359	2008	7628	Perry Phillips Lake	L3	Y	41.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Boone	10300102		L	
360	2002	0218	Peruque Cr.	C	Y	10.9	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Nonpoint Source	Warren/ St. Charles	07110009	3	M	
361	2012	0215	Peruque Cr.	P1	Y	9.6	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	St. Charles	07110009		M	
362	2016	0218	Peruque Cr.	C	Y	10.9	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Warren/ St. Charles	07110009		M	
363	2018	0785	Petite Saline Cr.	P	Y	21.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Cooper/ Moniteau	10300102		L	

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364	2010	2815	Pike Cr.	C	Y	6.0	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Butler	11010007		M	
365	2010	0312	Platte R.	P	Y	142.4	Miles	WBC B	Escherichia coli (W)	Rural NPS	Worth/Platte	10240012	2	H	2023
366	2012	1327	Pleasant Run Cr.	C	Y	7.6	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon	10290104		M	
367	2006	3120	Pole Cat Slough	P	Y	12.6	Miles	AQL	Oxygen, Dissolved (W)	Channelization, Nonpoint Source	Dunklin	08020204		M	
368	2014	3120	Pole Cat Slough	P	Y	12.6	Miles	AQL	Temperature, water (W)	Channelization, Nonpoint Source	Dunklin	08020204		M	
369	2020	7238	Pomme de Terre Lake	L2	Y	7675.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Hickory/ Polk	10290107	1	H	2023
370	2012	1440	Pomme de Terre R.	P	Y	69.1	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Webster/ Polk	10290107		L	
371	2020	7118	Pony Express Lake	L3	Y	256.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1	L	
372	2020	7755	Prairie Lake	L3	Y	22.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Charles	07110009	1	L	
373	2020	7213	Raintree Lake	L3	Y	248.1	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1	L	
374	2020	7083	Ray County Community Lake	L3	Y	23.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Ray	10300101	1	L	
375	2018	0743	Renfro Cr.	C	Y	1.5	Miles	AQL	Oxygen, Dissolved (W)	Abandoned Mine Lands and Rural NPS	Callaway	10300102		L	
376	2016	7204	Rinquelin Trail Community Lake	L3	Y	27.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Maries	10290111		L	
377	2006	1710	River des Peres	P	Y	2.6	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis City	07140101		M	
378	2006	3972	River des Peres	C	Y	13.6	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
379	2012	1710	River des Peres	P	Y	2.6	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis City	07140101		M	
380	2016	3972	River des Peres	C	Y	13.6	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
381	2016	3972	River des Peres	C	Y	13.6	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
382	2018	4111	River des Peres trib.	C	Y	1.8	Miles	AQL	Chloride (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
383	2018	4111	River des Peres trib.	C	Y	1.8	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	

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384	2018	4111	River des Peres trib.	C	Y	1.8	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
385	2018	4106	Rock Creek	C	Y	6.2	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson/Clay	10300101		M	
386	2018	4106	Rock Creek	C	Y	6.2	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson/Clay	10300101		M	
387	2020	7086	Rocky Hollow Lake	L3	Y	20.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Clay	10300101	1	L	
388	2018	3577	Sadler Br.	C	Y	0.8	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Polk	10290106		L	
389	**2022**	**2859**	**Saline Cr.**	**P**	**N (1.7)**	**5.8**	**Miles**	**AQL**	**Nickel (W)**	**Madison Mine**	**Madison**	**08020202**		M	
390	2010	0594	Salt Cr.	C	Y	14.9	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Chariton	10280103		M	
391	2012	2113	Salt Pine Cr.	C	Y	1.2	Miles	AQL	Lead (S)	Barite tailings pond	Washington	07140104		M	
392	2012	2113	Salt Pine Cr.	C	Y	1.2	Miles	AQL	Zinc (S)	Barite tailings pond	Washington	07140104		M	
393	2012	0103	Salt R.	P1	Y	9.3	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ralls	07110007	2	L	
394	2006	0142	S. Fk. Salt R.	C	N (20.1)	40.1	Miles	AQL	Oxygen, Dissolved (W)	Mexico WWTF, Rural Nonpoint Source	Callaway/ Audrain	07110006		M	
395	2020	2865	Shays Cr.	C	Y	1.7	Miles	AQL	Lead (S)	Mine La Motte	Madison	08020202		L	
396	2020	7042	Shelbina Lake	L1	Y	52.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Shelby	07110005	1 2	L	
397	2020	7036	Shelbyville Lake	L1	Y	32.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Shelby	07110005	1 2	L	
398	2020	7333	Shepard Mountain Lake	L1	Y	21.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Iron	08020202	1 2	L	
399	2008	3222	Shoal Creek	P	Y	50.2	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Newton	11070207	2	L	
400	2014	3222	Shoal Creek	P	N (3.8)	50.2	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207	2	M	
401	2014	3222	Shoal Creek	P	N (4.3)	50.2	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207	2	M	
402	2014	3981	Shoal Creek trib.	C	Y	1.9	Miles	AQL	Cadmium (W)	Tanyard Hollow Pits	Jasper	11070207		M	
403	2020	3982	Shoal Creek trib.	C	Y	2.2	Miles	AQL	Cadmium (W)	Mill Tailings	Jasper	11070207		M	
404	2014	3981	Shoal Creek trib.	C	Y	1.9	Miles	AQL	Zinc (W)	Tanyard Hollow Pits	Jasper	11070207		M	
405	2014	3982	Shoal Creek trib.	C	Y	2.2	Miles	AQL	Zinc (W)	Mill Tailings	Jasper	11070207		M	
406	2018	3244	Silver Cr.	P	Y	1.9	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207		M	
407	2020	7502	Simpson Park Lake	L3	Y	64.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Louis	07140102	1	L	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
408	2002	7502	Simpson Park Lake	L3	Y	64.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Louis	07140102		L	
409	2012	3259	S. Indian Cr.	P	Y	8.7	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	McDonald/ Newton	11070208	3	M	
410	2014	3754	Slater Br.	C	Y	3.7	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Jasper	11070207	5	L	
411	**2022**	**7077**	**Smithville Lake**	**L2**	**Y**	**7738.0**	**Acres**	**AQL**	**Chlorophyll-a (W)**	**Nonpoint Source**	**Clay**	**10240012**	**1 2**	L	
412	2008	0399	Sni-a-bar Cr.	P	Y	36.6	Miles	AQL	Oxygen, Dissolved (W)	Municipal Point Source Discharges, Source Unknown	Jackson/ Lafayette	10300101		M	
413	2012	0224	Spencer Cr.	C	Y	1.5	Miles	AQL	Chloride (W)	Road/Bridge Runoff, Non-construction	St. Charles	07110009		M	
414	2016	5007	Spring Branch	C	N (1.4)	3.1	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	St. Louis	07140102		M	
415	2018	5004	Spring Branch	C	Y	6.7	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
416	2018	5004	Spring Branch	C	Y	6.7	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jackson	10300101		M	
417	2006	3160	Spring R.	P	Y	61.7	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/ Jasper	11070207	5	L	
418	2010	3164	Spring R.	P	Y	8.8	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
419	2010	3165	Spring R.	P	Y	11.9	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
420	2018	4112	Spring River trib.	C	Y	4.0	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Jasper	11070207	5	L	
421	2018	2677	Spring Valley Cr.	P	Y	10.8	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Shannon	11010008		L	
422	2020	7149	Sterling Price Community Lake	L3	Y	23.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Chariton	10280202	1	L	
423	2006	3135	Stevenson Bayou	C	Y	7.4	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Mississippi	08020201		M	
424	2006	3138	St. Johns Ditch	P	Y	15.3	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	New Madrid	08020201		L	
425	**2022**	**2890**	**Stouts Cr.**	**P**	**N (1)**	**7.3**	**Miles**	**AQL**	**Oxygen, Dissolved (W)**	**Ironton WWTF**	**Iron**	**08020202**		L	
426	**2022**	**2893**	**Stouts Cr.**	**P**	**N (0.7)**	**4.0**	**Miles**	**AQL**	**Oxygen, Dissolved (W)**	**Ironton WWTF**	**Iron**	**08020202**		L	
427	**2022**	**0959**	**Straight Fk.**	**C**	**N (4.9)**	**6.0**	**Miles**	**WBC B**	**Escherichia coli (W)**	**Nonpoint Source**	**Morgan**	**10300102**		L	
428	2006	0686	Sugar Cr.	P	Y	6.8	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Randolph	10280203		M	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
429	2018	4108	Sugar Creek	C	Y	1.8	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
430	2018	4108	Sugar Creek	C	Y	1.8	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		M	
431	2014	7166	Sugar Creek Lake	L1	Y	308.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Randolph	10280203	2	L	
432	2020	7294	Sunnen Lake	L3	Y	206.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Washington	07140104	1	L	
433	2006	7399	Sunset Lake	L3	Y	6.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cole	10300102		L	
434	2002	7313	Table Rock Lake	L2	Y	41747.0	Acres	AQL	Chlorophyll-a (W)	Municipal Point Source Discharges, Nonpoint Source	Stone	11010001	1	M	
435	2002	7313	Table Rock Lake	L2	Y	41747.0	Acres	AQL	Nitrogen, Total (W)	Municipal Point Source Discharges, Nonpoint Source	Stone	11010001	1	M	
436	2016	7352	Thirtyfour Corner Blue Hole	L3	Y	9.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Mississippi	08010100		L	
437	2020	7173	Thomas Hill Reservoir	L2	Y	4400.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Randolph	10280203	1 2	L	
438	2012	3243	Thurman Cr.	P	Y	3.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070207	5	L	
439	2018	2114	Trib. Old Mines Cr.	C	Y	1.5	Miles	AQL	Lead (S)	Barite tailings pond	Washington	07140104		H	2022
440	2010	2114	Trib. Old Mines Cr.	C	Y	1.5	Miles	AQL	Sedimentation/ Siltation (S)	Barite tailings pond	Washington	07140104		H	2022
441	2018	2114	Trib. Old Mines Cr.	C	Y	1.5	Miles	AQL	Zinc (S)	Barite tailings pond	Washington	07140104		H	2022
442	2006	3490	Trib. to L. Muddy Cr.	C	Y	1.0	Miles	AQL	Chloride (W)	Tyson Foods	Pettis	10300103		L	
443	2006	3589	Trib. to Wolf Cr.	C	Y	1.5	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	St. Francois	08020202		M	
444	2006	0074	Troublesome Creek	C	N (6.1)	56.5	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Knox	07110003		M	
445	2012	0074	Troublesome Creek	C	Y	56.5	Miles	AQL	Sedimentation/ Siltation (S)	Habitat Mod.-other than Hydromod.	Knox/ Marion	07110003		L	
446	2016	3174	Truitt Cr.	P	Y	1.5	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
447	2012	3175	Truitt Creek	C	Y	5.2	Miles	SCR	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
448	2006	3216	Turkey Cr.	P	Y	7.7	Miles	AQL	Cadmium (S)	Tri-State Mining District	Jasper	11070207		M	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
449	2006	3217	Turkey Cr.	P	Y	6.1	Miles	AQL	Cadmium (S)	Tri-State Mining District	Jasper	11070207		M	
450	2014	3282	Turkey Cr.	P	Y	2.4	Miles	AQL	Cadmium (S)	Bonne Terre chat pile	St. Francois	07140104		H	2022
451	2006	3216	Turkey Cr.	P	Y	7.7	Miles	AQL	Cadmium (W)	Tri-State Mining District	Jasper	11070207		M	
452	2014	3282	Turkey Cr.	P	Y	2.4	Miles	AQL	Copper (S)	Bonne Terre chat pile	St. Francois	07140104		H	2022
453	2006	3216	Turkey Cr.	P	N (4.5)	7.7	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jasper	11070207	5	L	
454	2006	3217	Turkey Cr.	P	Y	6.1	Miles	WBC A	Escherichia coli (W)	Urban Runoff/ Storm Sewers	Jasper	11070207	5	L	
455	2012	0751	Turkey Cr.	C	Y	6.3	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Boone	10300102		M	
456	2006	3217	Turkey Cr.	P	Y	6.1	Miles	AQL	Lead (S)	Tri-State Mining District	Jasper	11070207		M	
457	2008	3216	Turkey Cr.	P	Y	7.7	Miles	AQL	Lead (S)	Tri-State Mining District	Jasper	11070207		M	
458	2014	3282	Turkey Cr.	P	Y	2.4	Miles	AQL	Lead (S)	Bonne Terre chat pile	St. Francois	07140104		H	2022
459	2006	3282	Turkey Cr.	P	Y	2.4	Miles	AQL	Lead (W)	Bonne Terre chat pile	St. Francois	07140104		H	2022
460	2014	3282	Turkey Cr.	P	Y	2.4	Miles	AQL	Nickel (S)	Bonne Terre chat pile	St. Francois	07140104		H	2022
461	2018	2985	Turkey Cr.	C	N (2.3)	3.1	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source, Puxico WWTF	Stoddard	08020203		L	
462	2006	3216	Turkey Cr.	P	Y	7.7	Miles	AQL	Zinc (S)	Tri-State Mining District	Jasper	11070207		M	
463	2006	3217	Turkey Cr.	P	Y	6.1	Miles	AQL	Zinc (S)	Tri-State Mining District	Jasper	11070207		M	
464	2014	3282	Turkey Cr.	P	Y	2.4	Miles	AQL	Zinc (S)	Bonne Terre chat pile	St. Francois	07140104		H	2022
465	2014	3983	Turkey Creek trib.	C	Y	2.9	Miles	AQL	Cadmium (S)	Abandoned Smelter Site	Jasper	11070207		M	
466	2016	3983	Turkey Creek trib.	C	Y	2.9	Miles	AQL	Cadmium (W)	Abandoned Smelter Site	Jasper	11070207		M	
467	2016	3984	Turkey Creek trib.	C	Y	2.2	Miles	AQL	Cadmium (W)	Leadwood Hollow pits	Jasper	11070207		M	
468	2014	3983	Turkey Creek trib.	C	Y	2.9	Miles	AQL	Lead (S)	Abandoned Smelter Site	Jasper	11070207		M	
469	2014	3983	Turkey Creek trib.	C	Y	2.9	Miles	AQL	Zinc (S)	Abandoned Smelter Site	Jasper	11070207		M	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
470	2014	3983	Turkey Creek trib.	C	Y	2.9	Miles	AQL	Zinc (W)	Abandoned Smelter Site	Jasper	11070207		M	
471	2014	3984	Turkey Creek trib.	C	Y	2.2	Miles	AQL	Zinc (W)	Leadwood Hollow pits	Jasper	11070207		M	
472	2014	3985	Turkey Creek trib.	C	Y	1.6	Miles	AQL	Zinc (W)	Chitwood Hollow pits	Jasper	11070207		M	
473	2016	4079	Twomile Creek	C	Y	5.6	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
474	2020	7154	Unionville Reservoir	L3	Y	74.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Putnam	10280201	1	L	
475	2016	7099	Unity Lake # 2	L1	Y	26.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101	2	L	
476	2020	7051	Vandalia Community Lake	L3	Y	35.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Audrain	07110008	1	L	
477	2020	7032	Vandalia Reservoir	L1	Y	28.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Pike	07110007	1 2	L	
478	2016	4097	Watkins Creek trib.	C	Y	1.2	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
479	2016	4097	Watkins Creek trib.	C	Y	1.2	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
480	2016	4098	Watkins Creek trib.	C	Y	1.2	Miles	SCR	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
481	2016	4098	Watkins Creek trib.	C	Y	1.2	Miles	WBC B	Escherichia coli (W)	Urban Runoff/ Storm Sewers	St. Louis	07140101		L	
482	2020	7072	Waukomis Lake	L3	Y	76.0	Acres	AQL	Phosphorus, Total (W)	Nonpoint Source	Platte	10240011	1	L	
483	2012	7071	Weatherby Lake	L3	Y	185.0	Acres	AQL	Chlorophyll-a (W)	Urban Runoff/ Storm Sewers	Platte	10240011	1	L	
484	2012	7071	Weatherby Lake	L3	Y	185.0	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Platte	10240011		L	
485	2010	7071	Weatherby Lake	L3	Y	185.0	Acres	AQL	Nitrogen, Total (W)	Urban Runoff/ Storm Sewers	Platte	10240011	1	L	
486	2014	7071	Weatherby Lake	L3	Y	185.0	Acres	AQL	Phosphorus, Total (W)	Urban Runoff/ Storm Sewers	Platte	10240011	1	L	
487	2006	1317	W. Fk. Dry Wood Cr.	C	Y	8.1	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon	10290104		M	
488	2008	1504	Whetstone Cr.	P	Y	12.2	Miles	AQL	Oxygen, Dissolved (W)	Rural NPS	Wright	10290201		M	
489	2010	3182	White Oak Cr.	C	Y	18.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/ Jasper	11070207	5	L	
490	2012	1700	Wildhorse Cr.	C	Y	3.9	Miles	WBC B	Escherichia coli (W)	Rural, Residential Areas	St. Louis	10300200		M	

Row #	Year	WBID	Waterbody	Class	Entire WB Impaired	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
491	2010	3171	Williams Cr.	P	Y	1.0	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
492	2010	3172	Williams Cr.	P	Y	8.5	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	5	L	
493	2012	3594	Williams Cr.	P	Y	1.0	Miles	WBC B	Escherichia coli (W)	Rural NPS	St. Louis	07140102		M	
494	2014	3280	Willow Br.	P	Y	2.2	Miles	AQL	Cadmium (S)	Mill Tailings	Newton	11070206		M	
495	2014	3280	Willow Br.	P	Y	2.2	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070206		M	
496	2020	7438	Willow Brook Lake	L1	Y	53.0	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1 2	L	
497	2006	0955	Willow Fk.	C	Y	6.8	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Moniteau	10300102		M	
498	2006	0956	Willow Fork tributary	C	Y	0.5	Miles	AQL	Oxygen, Dissolved (W)	Tipton WWTF	Moniteau	10300102		M	
499	1998	2375	Wilsons Cr.	P	Y	14.0	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Nonpoint Source	Greene	11010002	3	L	
500	2006	2375	Wilsons Cr.	P	Y	14.0	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Greene/ Christian	11010002		L	
501	2014	2429	Woods Fk.	C	Y	5.5	Miles	AQL	Fishes Bioassessments/ Unknown (W)	Source Unknown	Christian	11010003	3	M	

Key To List:

Bolded rows are new listings for the 2022 listing cycle

Row #: Row number that is not unique to any water, but is simply a count of the rows (listings)

Year: Year this waterbody/pollutant pair was added to the 303(d) List

WBID: Unique waterbody identification number. Clicking the link will bring up a WQA Public Search webpage with the available data for that WBID

Waterbody: Name of the waterbody.

Class: Waterbody Classification in Missouri State Water Quality Standards: P - Permanently Flowing Waters, C - Intermittently Flowing Waters, L1 - Drinking Water Reservoirs, L2 - Large Multi-purpose Lakes, L3 - Other Recreational Lakes, US - Unclassified Stream, UL - Unclassified Lake

Entire WB Impaired: Y= Yes the entire waterbody is considered impaired; N= No the entire waterbody is not considered impaired, if "N" then impaired size is listed in parentheses.

WB Size: Size of entire waterbody segment

IU: Impaired Use

AQL - Protection of Warm Water Aquatic Life ; CLF - Cool-Water Fishery ; CLD - Cold-Water Fishery ; DWS - Drinking Water Supply ; GEN - General Criteria ; HHP - Human-Health Protection (Fish Consumption) ; SCR - Secondary Contact Recreation; WBC A - Whole Body Contact Recreation A (Designated Public Swimming Areas); WBC B - Whole Body Contact Recreation B (Those areas not considered WBC A)

Pollutant: The reason or cause for the water being listed as impaired

Media Indicators: (W) - The pollutant is in the water ; (S) - The pollutant is in the sediment ; (T) - The pollutant is in the tissue of an organism ; If no media indicator is shown the pollutant is in the water

Source: The source of the pollutant causing the impairment

County Up/Down: The county of the upstream end and downstream end of the segment that is impaired. Clicking the link will bring up a map viewer displaying the location of the impaired portion of the waterbody.

Key To List (continued):

Comment:

1 - Nutrient related impairment

2 - Water is a Public Drinking Water Supply

3 - This water is listed for either "Aquatic Macroinvertebrate Bioassessment/Unknown (W)" or "Fishes Bioassessment/Unknown (W)" This water lacks the necessary information to point to a discrete pollutant and does not show signs of habitat impairment. Since the Department currently cannot point to a specific pollutant as the cause, the water is being listed for the observed effect as the reason the water is impaired.

4 - Trend analysis shows this water will exceed WQS within 5 years. See the Listing Methodology Document and Nutrient Implementation Plan for more information.

5 - This water is being prioritized as low for TMDL development due to 319 watershed management plans being implemented in the watershed.

TMDL Priority: H=High, M=Medium, L=Low

TMDL Schedule Year: Year that a Total Maximum Daily Load is scheduled to be written

5 Alt: Water has an alternative restoration plan accepted by the department and EPA. The department has identified this water as a low priority for TMDL development.

Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

Water Quality Data Search

Aquatic Macroinvertebrate Biological Assessment Reports

Missouri Department of Natural Resources

2022 Section 303(d) Delisted Waters

Proposed Delist for EPA Approval. CWC approved on April 12, 2023

Row #	Year	WBID	Waterbody Name	Pollutant	Delist Reason	Delist Comment	County Up/Down	HUC 8
1	2022	3224	Beef Br.	Cadmium (W)	WQS attained; due to change in WQS	WQS for dissolved cadmium in water changed. Beef Br is now meeting the standard.	Newton	11070207
2	2022	3224	Beef Br.	Zinc (W)	WQS attained; due to change in WQS	WQS changed to use media hardness instead of 25 percentile. Zinc samples taken in stable flow conditions within last 3 years of data indicate the water is meeting the standard.	Newton	11070207
3	2022	3980	Bens Branch	Cadmium (S)	4A - TMDL approved or established by EPA	EPA approved TMDL 4/29/2022.	Jasper	11070207
4	2022	3980	Bens Branch	Cadmium (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 4/29/2022.	Jasper	11070207
5	2022	3980	Bens Branch	Lead (S)	4A - TMDL approved or established by EPA	EPA approved TMDL 4/29/2022.	Jasper	11070207
6	2022	3980	Bens Branch	Zinc (S)	4A - TMDL approved or established by EPA	EPA approved TMDL 4/29/2022.	Jasper	11070207
7	2022	3980	Bens Branch	Zinc (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 4/29/2022.	Jasper	11070207
8	2022	1344	Cedar Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL on 4/8/2020.	Cedar	10290106
9	2022	3203	Center Cr.	Cadmium (S)	4A - TMDL approved or established by EPA	EPA Approved TMDL on 4/29/22	Jasper	11070207
10	2022	3203	Center Cr.	Lead (S)	4A - TMDL approved or established by EPA	EPA approved TMDL on 4/29/22	Jasper	11070207
11	2022	5003	Center Creek trib.	Cadmium (W)	4A - TMDL approved or established by EPA	EPA Approved TMDL on 4/29/22	Jasper	11070207
12	2022	5003	Center Creek trib.	Lead (W)	4A - TMDL approved or established by EPA	EPA Approved TMDL on 4/29/22	Jasper	11070207
13	2022	5003	Center Creek trib.	Zinc (W)	4A - TMDL approved or established by EPA	EPA Approved TMDL on 4/29/22	Jasper	11070207
14	2022	1333	Clear Cr.	Oxygen, Dissolved (W)	WQS attained; recovery reason unknown	Updated data shows DO levels within WQS	Vernon/ St. Clair	10290105
15	2022	7326	Clearwater Lake	Phosphorus, Total (W)	WQS attained; recovery reason unknown	Lake is meeting site-specific total phosphorus criteria based on most recent 7 years of data. Lake is still impaired for site-specific chlorophyll-a criteria.	Reynolds/ Wayne	11010007
16	2022	1706	Coldwater Cr.	Chloride (W)	WQS attained; recovery reason unknown	Chronic exceedances only occur during high flow events and do not persist for 96 hours.	St. Louis	10300200
17	2022	3826	Deer Creek	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 6/26/2019.	St. Louis/ St. Louis City	07140101
18	2022	2166	Eaton Br.	Lead (W)	WQS attained; due to change in WQS	WQS changed to use median hardness, lead in water no longer exceeds criteria.	St. Francois	07140104
19	2022	610	E. Fk. Locust Cr.	Chloride (W)	WQS attained; recovery reason unknown	Data collected 2018-22 indicates the stream is now attaining the chronic chloride criterion.	Sullivan	10280103
20	2022	1704	Fee Fee Cr. (new)	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 10/14/2020	St. Louis	10300200
21	2022	2168	Flat River	Cadmium (W)	WQS attained; due to change in WQS	WQS changed for cadmium and hardness used in equation, cadmium in water no longer exceeds criteria.	St. Francois	07140104

Row #	Year	WBID	Waterbody Name	Pollutant	Delist Reason	Delist Comment	County Up/Down	HUC 8
22	2022	7147	Fountain Grove Lakes	Chlorophyll-a (W)	Status unknown - Orig listing in error	Fountain Groves Lakes was listed by EPA in 2020. Data driving the listing was collected only from Jo Shelby Lake. Jo Shelby was assigned its own WBID. Joe Shelby Lake is listed as impaired for Chla.	Linn	10280103
23	2022	7426	Garden City New Lake	Chlorophyll-a (W)	WQS attained; recovery reason unknown	Lake was listed as impaired based on 2012 and 2011 data. 2013 data was missing. 2014 and 2013 data indicate lake is unimpaired. Incomplete 2018 data supports unimpaired judgment.	Cass	10290108
24	2022	2184	Grand Glaize Creek	Mercury in Fish Tissue (T)	WQS attained; original listing incorrect	Tissue samples were collected in and the impairment is in Simpson Park Lake not Grand Glaize Cr. Simpson Park Lake historically was included as part of Grand Glaize Cr. but the lake was recently split off as its own WBID.	St. Louis	07140102
25	2022	7385	Harmony Mission Lake	Chlorophyll-a (W)	WQS attained; new assessment method	Lake originally listed as impaired due exceeding the Chl*a* ST and EF C in 2017. Toxins values are used as surrogates for cyanobacteria cell counts. 2022 LMD was updated to use 8 µg/l for eutrophication factor C. Microcystin is below this updated value.	Bates	10290103
26	2022	7386	Harrison County Lake	Mercury in Fish Tissue (T)	WQS attained; recovery reason unknown	New data indicates long term average is <0.3 mg/kg.	Harrison	10280101
27	2022	1251	Honey Cr.	Oxygen, Dissolved (W)	WQS attained; recovery reason unknown	Honey Cr sampled in 2020 and 2021 with no DO exceedances. Last exceedance occurred in 2011. With the inclusion of more recent data, the binomial probability error rate is 0.16 which is above the minimum acceptable rate of 0.1.	Henry	10290108
28	2022	1251	Honey Cr.	Sulfates (W)	WQS attained; due to restoration action	Honey Creek was sampled in 2020 and 2021. There was only one exceedance of the SO4 criteria in the last 3 years of available data.	Henry	10290108
29	2022	3413	Horseshoe Cr.	Oxygen, Dissolved (W)	4C - Not caused by a pollutant	Low DO values observed are due to non-flowing conditions. Specific conductivity and nutrient data also indicate the stream is not experiencing low DO due to eutrophication or other discrete pollutants. Oak Grove WWTF no longer discharges to stream.	Lafayette/ Jackson	10300101
30	2022	7029	Hunnewell Lake	Chlorophyll-a (W)	Status unknown - Orig listing in error	The Department updated/corrected past data from UMC and included more recent data in the trend analysis. Trend analysis is no longer statistically significant and does not indicate exceedance within 5 years.	Shelby	07110004
31	2022	7114	King City New Reservoir	Chlorophyll-a (W)	WQS attained; original listing incorrect	The coordinates and lake names were mismatched between the 7113 and 7114 reservoirs. 7114 was incorrectly listed based on data from 7113. Data from 7114 reservoir indicates the reservoir is meeting WQS. 7113 will be listed as impaired.	Gentry	10280101
32	2022	7606	Lac Shayne	Chlorophyll-a (W)	WQS attained; recovery reason unknown	Water listed by EPA during the 2020 cycle. Additional 2019 and 2020 data indicates attainment.	St. Francois/ Washington	07140104
33	2022	7049	Lake Lincoln	Chlorophyll-a (W)	WQS attained; recovery reason unknown	Additional 2019 and 2020 data indicates attainment based on most recent 7 years of available data.	Lincoln	07110008

Row #	Year	WBID	Waterbody Name	Pollutant	Delist Reason	Delist Comment	County Up/Down	HUC 8
34	2022	3105	Lateral #2 Main Ditch	Ammonia, Total (W)	WQS attained; due to restoration action	Facility upgraded in 2016-2017. Data collected since upgrade indicates ammonia criteria is being met.	Stoddard	08020204
35	2022	1529	L. Beaver Cr.	Sedimentation/Siltation (S)	WQS attained; due to restoration action	A 2020 statistical analysis of 2018-2019 sediment study indicates that sedimentation in L. Beaver is no different than control stream.	Phelps	10290203
36	2022	3279	L. Lost Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 1/17/2023.	Newton	11070206
37	2022	2763	Logan Cr.	Lead (S)	WQS attained; due to restoration action	New sediment data indicates the geometric mean for lead is below the 150% PEC.	Reynolds	11010007
38	2022	3278	Lost Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 1/17/2023	Newton	11070206
39	2022	2814	Main Ditch	Ammonia, Un-ionized (W)	WQS attained; due to restoration action	2019 waste load allocation study data indicates the ammonia standard is being met.	Butler	11010007
40	2022	2814	Main Ditch	pH (W)	WQS attained; due to restoration action	2019 waste load allocation study grab/sonde data indicates pH standard is being met.	Butler	11010007
41	2022	2814	Main Ditch	Temperature, water (W)	WQS attained; recovery reason unknown	2019 waste load allocation study grab/sonde data indicates temperature standard is being met.	Butler	11010007
42	2022	3839	Maline Creek	Escherichia coli (W)	WQS attained; recovery reason unknown	Maline Creek has only SCR. Each of the last three years geometric means are below the SCR criteria.	St. Louis City	07140101
43	2022	1308	Marmaton R.	Oxygen, Dissolved (W)	WQS attained; due to restoration action	The Ft. Scott Kansas WWTF upgraded around 2010. Using only data post upgrade for assessment, water is no longer impaired. This stream was not on the 2020 List because of the EPA approved TMDL. Water is no longer impaired.	Vernon	10290104
44	2022	2183	Meramec R.	Lead (S)	WQS attained; recovery reason unknown	Additional data collected in 2022 incorporated into the assessment indicates the lead geometric mean is below the 150% PEC.	St. Louis	07140102
45	2022	3263	Middle Indian Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 5/12/2021.	Newton	11070208
46	2022	1604	Missouri R.	Escherichia coli (W)	WQS attained; recovery reason unknown	Data for four sites spread throughout the WBID from 2018-20 indicate WBC and SCR uses are being met.	Gasconade/ St. Louis	10300200
47	2022	7301	Monsanto Lake	Chlorophyll-a (W)	WQS attained; original listing incorrect	Values for surface samples and samples collected at depth in 2017 were erroneously summed. This error was corrected resulting in Monsanto Lake meeting SSC for Chl*a*. Lake remains impaired for TN.	St. Francois	07140104
48	2022	7301	Monsanto Lake	Phosphorus, Total (W)	WQS attained; original listing incorrect	Values for surface samples and samples collected at depth in 2017 were erroneously summed. This error was corrected resulting in Monsanto Lake meeting SSC for TP. Lake remains impaired for TN.	St. Francois	07140104
49	2022	3260	N. Indian Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 5/12/2021.	Newton	11070208
50	2022	942	N. Moreau Cr.	Oxygen, Dissolved (W)	WQS attained; due to restoration action	The California WWTF upgraded in 2005 to include activated sludge and clarifiers. Data in previous assessments included data pre upgrade. Using only data post upgrade for assessment, water is no longer impaired. Upstream was previously listed incorrectly.	Moniteau/ Cole	10300102

Row #	Year	WBID	Waterbody Name	Pollutant	Delist Reason	Delist Comment	County Up/Down	HUC 8
51	2022	7316	Noblett Lake	Chlorophyll-a (W)	WQS attained; original listing incorrect	Original listing used uncorrected chlorophyll rather than corrected chlorophyll. Using the corrected chlorophyll data, the geometric mean is below site specific criteria. Lake is still impaired for total phosphorus.	Douglas	11010006
52	2022	550	No Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA Approved TMDL 8/30/2022	Grundy/ Livingston	10280102
53	2022	279	Nodaway R.	Escherichia coli (W)	4A - TMDL approved or established by EPA	TMDL for E. coli approved 12/20/2021	Nodaway/ Andrew	10240010
54	2022	7164	Rothwell Lake	Chlorophyll-a (W)	WQS attained; recovery reason unknown	Listed based on 2016 and 2018 exceeding chlorophyll-a criteria. No exceedances of the criteria or any of the screening thresholds/eutrophication factors in 2019-20.	Randolph	10280203
55	2022	2835	Saint Francis River	Oxygen, Dissolved (W)	WQS attained; due to restoration action	WWTF updates since the 2006 TMDL appear to have corrected low DO below the WWTF. This stream was not on the 2020 List because of 4B, but water is now no longer impaired.	St. Francois/ Wayne	08020202
56	2022	2835	Saint Francis River	Temperature, water (W)	WQS attained; due to restoration action	WWTF updates since 2006 TMDL appear to have corrected elevated temperatures below the WWTF.	St. Francois/ Wayne	08020202
57	2022	893	Salt Fk.	Oxygen, Dissolved (W)	WQS attained; due to restoration action	Marshall SE upgraded their treatment plant from 2012-2015 which included disinfection, new headworks facility (screening, more solids removal), upgraded their clarifiers, and modified their sludge tanks. WQS are now being met.	Saline	10300104
58	2022	91	Salt R.	Oxygen, Dissolved (W)	4C - Not caused by a pollutant	Water body is still impaired. Low dissolved oxygen is due to hydromodification from the Mark Twain hydroelectric dam.	Ralls/ Pike	07110007
59	2022	655	S. Blackbird Cr.	Ammonia, Total (W)	WQS attained; recovery reason unknown	Only one exceedance of criteria in 2007; none in 2008; none in most recent data year (2021)	Putnam	10280201
60	2022	141	S. Fk. Salt R.	pH (W)	WQS attained; recovery reason unknown	Additional data brought binomial probability above 0.1. Water not impaired according to LMD.	Monroe	07110006
61	2022	1249	S. Grand R.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 6/1/2022	Cass/ Henry	10290108
62	2022	3259	S. Indian Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL 5/12/2021.	McDonald/ Newton	11070208
63	2022	959	Straight Fk.	Chloride (W)	WQS attained; due to restoration action	New permit limits resulted in attainment of chloride criteria. Was not on 2020 list because of 4B. Water is no longer impaired.	Morgan	10300102
64	2022	959	Straight Fk.	Oxygen, Dissolved (W)	WQS attained; due to restoration action	New permit limits resulted in attainment of dissolved oxygen criteria.	Morgan	10300102
65	2022	686	Sugar Cr.	pH (W)	WQS attained; due to restoration action	Exceedances have not occurred on WB since 2015. Past exceedances are limited to stream miles 1.1 to 2.6. Binomial probability for whole WB and for 1.1 to 2.6 are well above 0.1 criteria. pH TMDL approved 2002, but water is no longer impaired.	Randolph	10280203
66	2022	686	Sugar Cr.	Sulfate + Chloride (W)	WQS attained; recovery reason unknown	Last SO4+Cl exceedance occurred in 2018. Monitoring data from 2019-21 indicate SO4+Cl levels to now be well below the criteria.	Randolph	10280203

Row #	Year	WBID	Waterbody Name	Pollutant	Delist Reason	Delist Comment	County Up/Down	HUC 8
67	2022	7313	Table Rock Lake	Nutrient/Eutrophication Biol. Indicators (W)	WQS attained; due to change in WQS	This lake has site specific WQS, lake is listed as impaired for nitrogen and chlorophyll-a, this cause was from before site specific criteria was established. This cause is redundant to the other listings.	Stone	11010001
68	2022	549	Thompson R.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA Approved TMDL 8/30/2022	Harrison/ Livingston	10280102
69	2022	2850	Trace Cr.	pH (W)	WQS attained; recovery reason unknown	Data collected since original listing indicate stream is meeting WQS. TMDL approved 2004, water is no longer impaired.	Madison	08020202
70	2022	1420	Trib. to Goose Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved a TMDL for E.coli on 3/8/2022.	Lawrence	10290106
71	2022	2985	Turkey Cr.	Ammonia, Total (W)	WQS attained; due to restoration action	The Puxico WWTF upgraded their WWTF to address TSS, BOD, and ammonia in 2019-2020. Data collected post completion indicate ammonia values are meeting WQS in stream.	Stoddard	08020203
72	2022	3282	Turkey Cr.	Cadmium (W)	WQS attained; due to change in WQS	WQS changed to median hardness rather than 25th percentile and WQS cadmium equation changed. Water now meets WQS.	St. Francois	07140104
73	2022	3282	Turkey Cr.	Zinc (W)	WQS attained; due to change in WQS	WQS changed to median hardness rather than 25th percentile and WQS zinc equation changed. Water now meets WQS.	St. Francois	07140104
74	2022	1414	Turnback Cr.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved a TMDL for E.coli on 3/8/2022.	Lawrence/ Dade	10290106
75	2022	1708	Watkins Creek	Chloride (W)	WQS attained; recovery reason unknown	Over the most recent three years of data, chronic chloride exceedances occur during unstable hydrologic events, duration of chloride exceedances cannot be shown to occur for 96 hours in duration.	St. Louis	07140101
76	2022	560	Weldon R.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA Approved TMDL 8/30/2022	Mercer/ Grundy	10280102
77	2022	3280	Willow Br.	Escherichia coli (W)	4A - TMDL approved or established by EPA	EPA approved TMDL on 1/17/2023.	Newton	11070206

Key To List:

Row #: Row number that is not unique to any water, but is simply a count of the rows (listings).

Year = Year this waterbody/pollutant pair was delisted

WBID = Unique waterbody identification number

Delist Cause = Pollutant or cause for which the waterbody was originally listed

Delist Reason = Reason/Justification for delisting action

Delist Comment = Comments or additional justification explaining the delisting action

Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm

APPENDIX G - LAKE NUTRIENT TREND DATA

Chlorophyll-a Trends

Lake Name	WBID	# of Data Years	Projected Chl*a* Exceedance Year	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
				Slope (Δ µg/L Chl*a* per year)	*p*-value	Trend	Assessment		
Atkinson Lake	7234	24	1921	-0.044	0.901	Inconclusive	Inconclusive	NNC	Plains
Belleview Lake (LaBelle # 2)	7023	11	1991	+0.830	0.640	Inconclusive	Impaired for Chl*a*	NNC	Plains
Bilby Ranch Lake	**7368**	**20**	**2007**	**-0.663**	**0.021**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Blind Pony Lake	7189	19	1991	+0.950	0.327	Inconclusive	Impaired for Chl*a*	NNC	Plains
Blue Springs Lake	7358	22	2053	+0.225	0.075	Inconclusive	Meeting nutrient criteria	NNC	Plains
Brookfield Lake	7138	21	1770	-0.098	0.156	Inconclusive	Meeting nutrient criteria	NNC	Plains
Butler Lake	7229	10	2036	-0.816	1.000	Inconclusive	Impaired for Chl*a*	NNC	Plains
Deer Ridge Community Lake	7015	24	2018	+0.832	0.056	Inconclusive	Impaired for Chl*a*	NNC	Plains
Eagle Lake (Cameron # 3)	7119	20	2005	-0.579	0.096	Inconclusive	Inconclusive	NNC	Plains
Grindstone Lake (Cameron # 4)	7384	18	2008	+0.628	0.344	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harrison County Lake	7386	21	2020	-0.776	0.124	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harry S. Truman Reservoir	**7207**	**24**	**2034**	**+0.475**	**0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Hazel Hill Lake	7387	21	1997	+0.434	0.319	Inconclusive	Impaired for Chl*a*	NNC	Plains
Henry Sever Lake	7024	24	2063	+0.227	0.107	Inconclusive	Inconclusive	NNC	Plains
Higginsville Reservoir South	**7190**	**23**	**2004**	**+1.423**	**0.006**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Hunnewell Lake	7029	24	2057	+0.170	0.442	Inconclusive	Inconclusive	NNC	Plains
Kraut Run Lake	**7056**	**19**	**1990**	**+2.467**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Lake Jacomo	7101	20	2155	+0.108	0.230	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lotawana	7091	13	1993	-0.352	0.360	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lucern	7248	14	2207	+0.184	0.443	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Saint Louis	**7054**	**20**	**2015**	**+0.618**	**0.015**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Lake Sainte Louise	**7055**	**16**	**2056**	**+0.340**	**0.008**	**Degrading**	**Meeting nutrient criteria**	**NNC**	**Plains**
Lake Tapawingo	**7103**	**12**	**2007**	**-1.352**	**0.002**	**Improving**	**Meeting nutrient criteria**	**NNC**	**Plains**
Lamar Lake	**7356**	**20**	**2025**	**-0.843**	**0.048**	**Improving**	**Impaired for Chl*a***	**NNC**	**Plains**
Little Dixie Lake	**7180**	**24**	**2009**	**+0.763**	**0.004**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**

Chlorophyll-a Trends

Lake Name	WBID	# of Data Years	Projected Chl*a* Exceedance Year	Nonparametric Trend Analysis: Slope (Δ µg/L Chl*a* per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Status: Trend	Water Quality Status: Assessment	Nutrient Criteria	Lake Ecoregion
Long Branch Lake	7171	10	2075	+0.108	0.876	Inconclusive	Inconclusive	NNC	Plains
Mark Twain Lake	7033	22	1688	-0.075	0.652	Inconclusive	Inconclusive	NNC	Plains
Monroe City Lake B	**7034**	**11**	**1998**	**+1.054**	**0.020**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Mozingo Lake	7402	20	2056	+0.424	0.315	Inconclusive	Impaired for Chl*a*	NNC	Plains
Nodaway Lake	**7076**	**21**	**2012**	**+0.910**	**0.005**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
North Lake	**7218**	**22**	**1991**	**+1.342**	**0.042**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Old Reservoir (Water Works)	7165	16	2060	-0.121	0.685	Inconclusive	Inconclusive	NNC	Plains
Raintree Lake	**7213**	**24**	**2024**	**+0.959**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Rothwell Lake	7164	19	2008	-0.459	0.108	Inconclusive	Inconclusive	NNC	Plains
Smithville Lake	7077	15	2039	+0.521	0.063	Inconclusive	Impaired for Chl*a*	NNC	Plains
Spring Fork Lake	7187	15	1879	+0.262	0.692	Inconclusive	Impaired for Chl*a*	NNC	Plains
Sugar Creek Lake	**7166**	**21**	**1992**	**-0.445**	**0.032**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Tri-City Lake	7624	17	2013	+0.513	0.064	Inconclusive	Inconclusive	NNC	Plains
Unionville New Reservoir	7154	10	1914	+0.418	0.602	Inconclusive	Impaired for Chl*a*	NNC	Plains
Watkins Mill Lake	7087	20	2275	-0.022	0.974	Inconclusive	Meeting nutrient criteria	NNC	Plains
Fellows Lake	7237	21	1873	-0.123	0.057	Inconclusive	Inconclusive	NNC	Ozark Highlands
Hemitite Lake	**7331**	**20**	**2004**	**+5.028**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Ozark Highlands**
Lake of the Ozarks	**7205**	**35**	**2030**	**+0.159**	**0.027**	**Degrading**	**Inconclusive**	**NNC**	**Ozark Highlands**
Lake Springfield	7312	18	2018	-0.950	0.130	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Lake Wappapello	7336	22	2588	-0.247	0.735	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Little Prairie Lake	7287	21	2143	+0.022	0.786	Inconclusive	Inconclusive	NNC	Ozark Highlands
McDaniel Lake	7236	17	2000	-0.318	0.127	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Pomme de Terre Lake	7238	22	1977	-0.075	0.499	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Stockton Lake	7235	22	2110	+0.084	0.310	Inconclusive	Inconclusive	NNC	Ozark Highlands
Binder Lake	7185	21	1990	+0.656	0.124	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Lake Sherwood	7247	11	2064	+0.025	1.000	Inconclusive	Meeting nutrient criteria	NNC	Ozark Border
Manito Lake	7198	21	2018	+0.580	0.057	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border

Chlorophyll-a Trends

Lake Name	WBID	# of Data Years	Projected Chl*a* Exceedance Year	Nonparametric Trend Analysis: Slope (Δ µg/L Chl*a* per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Status: Trend	Water Quality Status: Assessment	Nutrient Criteria	Lake Ecoregion
Bowling Green New Lake	7004	23	-	+0.090	0.369	Inconclusive	Meeting nutrient criteria	SSC	Plains
Bowling Green Old Lake	7003	12	-	-0.388	0.755	Inconclusive	Impaired for TN, TP	SSC	Plains
Forest Lake	7151	23	-	+0.080	0.073	Inconclusive	Impaired for Chl*a*	SSC	Plains
Fox Valley Lake	**7008**	**21**	**-**	**+0.251**	**0.032**	**Degrading**	**Impaired for Chl*a*, TN, TP**	**SSC**	**Plains**
Lake Viking	7122	15	-	+0.134	0.322	Inconclusive	Meeting nutrient criteria	SSC	Plains
Waukomis Lake	**7072**	**15**	**-**	**+0.189**	**0.010**	**Degrading**	**Impaired for TP**	**SSC**	**Plains**
Weatherby Lake	**7071**	**21**	**-**	**+0.116**	**0.050**	**Degrading**	**Impaired for Chl*a*, TN, TP**	**SSC**	**Plains**
Clearwater Lake	7326	23	-	+0.022	0.673	Inconclusive	Impaired for Chl*a*	SSC	Ozark Highlands
Council Bluff Lake	7299	21	-	-0.034	0.085	Inconclusive	Meeting nutrient criteria	SSC	**Ozark Highlands**
Lac Capri	7297	21	-	+0.020	0.142	Inconclusive	Impaired for TN	SSC	Ozark Highlands
Lac Shayne	7606	22	-	+0.009	0.444	Inconclusive	Meeting nutrient criteria	SSC	Ozark Highlands
Lake Wauwanoka	7258	11	-	+0.022	0.858	Inconclusive	Impaired for TN	SSC	Ozark Border

Notes

Bold rows: significant trend *p*-value (0.05 threshold)

Degrading trend status: trend slopes positive and significant

Improving trend status: trend slopes negative and significant

Δ: delta, change in a parameter

WBID: waterbody identifier

NNC: ecoregional numeric nutrient criteria

SSC: site-specific nutrient criteria

Data normality could not be assumed, thus nonparametric trend analysis was conducted.
The Mann-Kendall test with the Thiel-Sen slope was used.

Chl*a*: Chlorophyll-a	Secchi: Secchi transparency	TN: Total nitrogen	TP: Total phosphorus	TSS: Total suspended solids

"Inconclusive" *trend* statuses indicate a lack of a significant trend and do not reflect trend regression line slopes.

"Inconclusive" *assessment* statuses indicate chlorophyll-a response impairment thresholds were not exceeded,
but at least one nutrient screening threshold was exceeded without a response assessment endpoint also being met.

Secchi Transparency Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ m Secchi per year)	*p*-value	Trend	Assessment		
Atkinson Lake	**7234**	**30**	**+0.005**	**0.010**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Belleview Lake (LaBelle # 2)	7023	10	-0.008	0.371	Inconclusive	Impaired for Chl*a*	NNC	Plains
Bilby Ranch Lake	7368	21	-0.008	0.165	Inconclusive	Inconclusive	NNC	Plains
Blind Pony Lake	7189	26	0.000	0.895	Inconclusive	Impaired for Chl*a*	NNC	Plains
Blue Springs Lake	7358	28	+0.005	0.071	Inconclusive	Meeting nutrient criteria	NNC	Plains
Brookfield Lake	7138	24	+0.010	0.164	Inconclusive	Meeting nutrient criteria	NNC	Plains
Butler Lake	7229	10	+0.002	1.000	Inconclusive	Impaired for Chl*a*	NNC	Plains
Deer Ridge Community Lake	7015	29	+0.007	0.209	Inconclusive	Impaired for Chl*a*	NNC	Plains
Eagle Lake (Cameron # 3)	7119	22	+0.003	0.163	Inconclusive	Inconclusive	NNC	Plains
Grindstone Lake (Cameron # 4)	7384	19	+0.003	0.434	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harrison County Lake	**7386**	**21**	**-0.022**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Harry S. Truman Reservoir	7207	29	+0.003	0.694	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hazel Hill Lake	7387	21	-0.005	0.546	Inconclusive	Impaired for Chl*a*	NNC	Plains
Henry Sever Lake	7024	28	+0.005	0.594	Inconclusive	Inconclusive	NNC	Plains
Higginsville Reservoir South	**7190**	**29**	**-0.007**	**0.027**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Hunnewell Lake	7029	29	+0.003	0.536	Inconclusive	Inconclusive	NNC	Plains
Kraut Run Lake	7056	25	+0.001	0.591	Inconclusive	Impaired for Chl*a*	NNC	Plains
Lake Jacomo	7101	27	+0.001	0.851	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lotawana	7091	15	+0.003	0.621	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lucern	7248	14	+0.025	0.584	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Saint Louis	**7054**	**23**	**+0.007**	**0.039**	**Improving**	**Impaired for Chl*a***	**NNC**	**Plains**
Lake Sainte Louise	**7055**	**20**	**+0.015**	**0.025**	**Improving**	**Meeting nutrient criteria**	**NNC**	**Plains**
Lake Tapawingo	7103	13	+0.008	0.246	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lamar Lake	7356	22	+0.003	0.652	Inconclusive	Impaired for Chl*a*	NNC	Plains
Little Dixie Lake	7180	34	-0.006	0.075	Inconclusive	Impaired for Chl*a*	NNC	Plains
Long Branch Lake	7171	7	-0.008	1.000	Inconclusive	Inconclusive	NNC	Plains
Mark Twain Lake	7033	31	0.000	1.000	Inconclusive	Inconclusive	NNC	Plains

Secchi Transparency Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ m Secchi per year)	*p*-value	Trend	Assessment		
Monroe City Lake B	7034	16	+0.002	0.470	Inconclusive	Impaired for Chl*a*	NNC	Plains
Mozingo Lake	**7402**	**20**	**-0.030**	**0.030**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Nodaway Lake	7076	21	-0.005	0.349	Inconclusive	Impaired for Chl*a*	NNC	Plains
North Lake	7218	26	-0.001	0.659	Inconclusive	Impaired for Chl*a*	NNC	Plains
Old Reservoir (Water Works)	7165	16	+0.011	0.444	Inconclusive	Inconclusive	NNC	Plains
Raintree Lake	**7213**	**29**	**+0.013**	**0.017**	**Improving**	**Impaired for Chl*a***	**NNC**	**Plains**
Rothwell Lake	7164	19	-0.011	0.363	Inconclusive	Inconclusive	NNC	Plains
Smithville Lake	**7077**	**16**	**-0.016**	**0.024**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Spring Fork Lake	7187	20	+0.004	0.091	Inconclusive	Impaired for Chl*a*	NNC	Plains
Sugar Creek Lake	7166	27	+0.002	0.404	Inconclusive	Inconclusive	NNC	Plains
Tri-City Lake	7624	20	0.000	0.897	Inconclusive	Inconclusive	NNC	Plains
Unionville New Reservoir	7154	15	-0.003	0.463	Inconclusive	Impaired for Chl*a*	NNC	Plains
Watkins Mill Lake	7087	24	+0.009	0.063	Inconclusive	Meeting nutrient criteria	NNC	Plains
Fellows Lake	**7237**	**29**	**-0.028**	**0.017**	**Degrading**	**Inconclusive**	**NNC**	**Ozark Highlands**
Hemitite Lake	**7331**	**20**	**-0.082**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Ozark Highlands**
Lake of the Ozarks	7205	42	-0.008	0.288	Inconclusive	Inconclusive	NNC	Ozark Highlands
Lake Springfield	7312	18	+0.001	0.940	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Lake Wappapello	7336	33	-0.001	0.951	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Little Prairie Lake	**7287**	**27**	**+0.044**	**< 0.001**	**Improving**	**Inconclusive**	**NNC**	**Ozark Highlands**
McDaniel Lake	7236	25	-0.011	0.243	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Pomme de Terre Lake	7238	30	-0.010	0.139	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Stockton Lake	**7235**	**30**	**-0.034**	**0.005**	**Improving**	**Inconclusive**	**NNC**	**Ozark Highlands**
Binder Lake	7185	24	0.000	0.941	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Lake Sherwood	7247	12	-0.007	0.945	Inconclusive	Meeting nutrient criteria	NNC	Ozark Border
Manito Lake	7198	21	+0.008	0.264	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Bowling Green New Lake	7004	26	-0.019	0.118	Inconclusive	Meeting nutrient criteria	SSC	Plains
Bowling Green Old Lake	**7003**	**9**	**-0.050**	**0.048**	**Degrading**	**Impaired for TN, TP**	**SSC**	**Plains**

Secchi Transparency Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ m Secchi per year)	*p*-value	Trend	Assessment		
Forest Lake	7151	31	-0.011	0.118	Inconclusive	Impaired for Chl*a*	SSC	Plains
Fox Valley Lake	**7008**	**21**	**-0.056**	**0.006**	**Degrading**	**Impaired for Chl*a*, TN, TP**	**SSC**	**Plains**
Lake Viking	7122	20	+0.014	0.456	Inconclusive	Meeting nutrient criteria	SSC	Plains
Waukomis Lake	7072	18	+0.003	0.711	Inconclusive	Impaired for TP	SSC	Plains
Weatherby Lake	7071	25	-0.006	0.624	Inconclusive	Impaired for Chl*a*, TN, TP	SSC	Plains
Clearwater Lake	7326	26	-0.008	0.427	Inconclusive	Impaired for Chl*a*	SSC	Ozark Highlands
Council Bluff Lake	7299	23	+0.020	0.291	Inconclusive	Meeting nutrient criteria	SSC	Ozark Highlands
Lac Capri	7297	25	+0.027	0.224	Inconclusive	Impaired for TN	SSC	Ozark Highlands
Lac Shayne	**7606**	**25**	**+0.066**	**0.002**	**Improving**	**Meeting nutrient criteria**	**SSC**	**Ozark Highlands**
Lake Wauwanoka	7258	12	-0.028	0.304	Inconclusive	Impaired for TN	SSC	Ozark Border

Notes

Bold rows: significant trend *p*-value (0.05 threshold)

Degrading trend status: trend slopes positive and significant

Improving trend status: trend slopes negative and significant

Δ: delta, change in a parameter

WBID: waterbody identifier

NNC: ecoregional numeric nutrient criteria

SSC: site-specific nutrient criteria

Data normality could not be assumed, thus nonparametric trend analysis was conducted. The Mann-Kendall test with the Thiel-Sen slope was used.

Chl*a*: Chlorophyll-a	Secchi: Secchi transparency	TN: Total nitrogen	TP: Total phosphorus	TSS: Total suspended solids

"Inconclusive" *trend* statuses indicate a lack of a significant trend and do not reflect trend regression line slopes.

"Inconclusive" *assessment* statuses indicate chlorophyll-a response impairment thresholds were not exceeded, but at least one nutrient screening threshold was exceeded without a response assessment endpoint also being met.

*For Secchi only: A "degrading" trend status is associated with a decreasing slope and "improving" with increasing.

Total Nitrogen Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis: Slope (Δ µg/L TN per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Status: Trend	Water Quality Status: Assessment	Nutrient Criteria	Lake Ecoregion
Atkinson Lake	7234	30	+0.007	0.080	Inconclusive	Inconclusive	NNC	Plains
Belleview Lake (LaBelle # 2)	7023	11	+4.943	0.533	Inconclusive	Impaired for Chl*a*	NNC	Plains
Bilby Ranch Lake	**7368**	**21**	**-14.336**	**0.017**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Blind Pony Lake	7189	26	+3.276	0.441	Inconclusive	Impaired for Chl*a*	NNC	Plains
Blue Springs Lake	7358	29	+0.586	0.767	Inconclusive	Meeting nutrient criteria	NNC	Plains
Brookfield Lake	7138	24	-3.096	0.107	Inconclusive	Meeting nutrient criteria	NNC	Plains
Butler Lake	7229	10	+9.292	1.000	Inconclusive	Impaired for Chl*a*	NNC	Plains
Deer Ridge Community Lake	**7015**	**30**	**+8.721**	**0.014**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Eagle Lake (Cameron # 3)	7119	22	-7.391	0.381	Inconclusive	Inconclusive	NNC	Plains
Grindstone Lake (Cameron # 4)	7384	19	+23.233	0.434	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harrison County Lake	7386	21	-6.773	0.381	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harry S. Truman Reservoir	7207	31	-3.576	0.211	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hazel Hill Lake	7387	21	+6.760	0.381	Inconclusive	Impaired for Chl*a*	NNC	Plains
Henry Sever Lake	7024	28	-7.852	0.297	Inconclusive	Inconclusive	NNC	Plains
Higginsville Reservoir South	7190	29	+10.808	0.149	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hunnewell Lake	7029	29	+1.541	0.707	Inconclusive	Inconclusive	NNC	Plains
Kraut Run Lake	**7056**	**25**	**+10.74**	**0.027**	**Inconclusive**	**Impaired for Chl*a***	**NNC**	**Plains**
Lake Jacomo	7101	27	-1.731	0.381	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lotawana	7091	15	-4.321	0.428	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lucern	7248	14	-2.374	0.743	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Saint Louis	**7054**	**24**	**-13.54**	**0.004**	**Improving**	**Impaired for Chl*a***	**NNC**	**Plains**
Lake Sainte Louise	**7055**	**20**	**+4.326**	**0.014**	**Degrading**	**Meeting nutrient criteria**	**NNC**	**Plains**
Lake Tapawingo	7103	13	-7.207	0.059	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lamar Lake	7356	22	+9.622	0.236	Inconclusive	Impaired for Chl*a*	NNC	Plains
Little Dixie Lake	**7180**	**34**	**+13.892**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Long Branch Lake	7171	25	-5.722	0.503	Inconclusive	Inconclusive	NNC	Plains
Mark Twain Lake	7033	31	-0.005	0.341	Inconclusive	Inconclusive	NNC	Plains

Total Nitrogen Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis: Slope (Δ µg/L TN per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Status: Trend	Water Quality Status: Assessment	Nutrient Criteria	Lake Ecoregion
Monroe City Lake B	7034	17	+9.135	0.192	Inconclusive	Impaired for Chl*a*	NNC	Plains
Mozingo Lake	7402	21	-0.937	0.833	Inconclusive	Impaired for Chl*a*	NNC	Plains
Nodaway Lake	7076	21	+11.453	0.194	Inconclusive	Impaired for Chl*a*	NNC	Plains
North Lake	**7218**	**26**	**+14.245**	**0.038**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Old Reservoir (Water Works)	**7165**	**16**	**-15.056**	**0.010**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Raintree Lake	7213	29	-4.356	0.378	Inconclusive	Impaired for Chl*a*	NNC	Plains
Rothwell Lake	7164	19	-1.177	0.889	Inconclusive	Inconclusive	NNC	Plains
Smithville Lake	7077	23	+6.608	0.535	Inconclusive	Impaired for Chl*a*	NNC	Plains
Spring Fork Lake	**7187**	**20**	**+18.158**	**0.003**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Sugar Creek Lake	7166	27	+4.754	0.088	Inconclusive	Inconclusive	NNC	Plains
Tri-City Lake	7624	23	+6.701	0.139	Inconclusive	Inconclusive	NNC	Plains
Unionville New Reservoir	7154	15	+8.414	0.583	Inconclusive	Impaired for Chl*a*	NNC	Plains
Watkins Mill Lake	7087	25	+0.665	0.797	Inconclusive	Meeting nutrient criteria	NNC	Plains
Fellows Lake	7237	29	+0.151	0.785	Inconclusive	Inconclusive	NNC	Ozark Highlands
Hemitite Lake	**7331**	**21**	**+54.301**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Ozark Highlands**
Lake of the Ozarks	7205	44	+0.001	0.804	Inconclusive	Inconclusive	NNC	Ozark Highlands
Lake Springfield	7312	18	-0.082	0.94	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Lake Wappapello	7336	34	+1.678	0.724	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Little Prairie Lake	7287	27	+0.808	0.692	Inconclusive	Inconclusive	NNC	Ozark Highlands
McDaniel Lake	7236	25	-3.392	0.234	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Pomme de Terre Lake	7238	30	+0.002	0.088	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Stockton Lake	7235	31	0.000	0.750	Inconclusive	Inconclusive	NNC	Ozark Highlands
Binder Lake	7185	24	+2.856	0.189	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Lake Sherwood	7247	12	-2.372	0.732	Inconclusive	Meeting nutrient criteria	NNC	Ozark Border
Manito Lake	7198	21	+4.809	0.526	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Bowling Green New Lake	7004	26	-0.549	0.86	Inconclusive	Meeting nutrient criteria	SSC	Plains
Bowling Green Old Lake	7003	12	-21.116	0.451	Inconclusive	Impaired for TN, TP	SSC	Plains

Total Nitrogen Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ µg/L TN per year)	*p*-value	Trend	Assessment		
Forest Lake	7151	31	-0.825	0.285	Inconclusive	Impaired for Chl*a*	SSC	Plains
Fox Valley Lake	**7008**	**21**	**+7.359**	**0.006**	**Degrading**	**Impaired for Chl*a*, TN, TP**	**SSC**	**Plains**
Lake Viking	7122	20	-1.831	0.673	Inconclusive	Meeting nutrient criteria	SSC	Plains
Waukomis Lake	7072	18	-2.063	0.174	Inconclusive	Impaired for TP	SSC	Plains
Weatherby Lake	**7071**	**25**	**+4.649**	**0.008**	**Degrading**	**Impaired for Chl*a*, TN, TP**	**SSC**	**Plains**
Clearwater Lake	**7326**	**27**	**-2.339**	**0.050**	**Improving**	**Impaired for Chl*a***	**SSC**	**Ozark Highlands**
Council Bluff Lake	7299	24	-1.812	0.107	Inconclusive	Meeting nutrient criteria	SSC	Ozark Highlands
Lac Capri	7297	25	+1.002	0.388	Inconclusive	Impaired for TN	SSC	Ozark Highlands
Lac Shayne	7606	25	+1.795	0.129	Inconclusive	Meeting nutrient criteria	SSC	Ozark Highlands
Lake Wauwanoka	7258	12	+5.183	0.064	Inconclusive	Impaired for TN	SSC	Ozark Border

Notes

Bold rows: significant trend *p*-value (0.05 threshold)

Degrading trend status: trend slopes positive and significant

Improving trend status: trend slopes negative and significant

Δ: delta, change in a parameter

WBID: waterbody identifier

NNC: ecoregional numeric nutrient criteria

SSC: site-specific nutrient criteria

Data normality could not be assumed, thus nonparametric trend analysis was conducted. The Mann-Kendall test with the Thiel-Sen slope was used.

Chl*a*: Chlorophyll-a	Secchi: Secchi transparency	TN: Total nitrogen	TP: Total phosphorus	TSS: Total suspended solids

"Inconclusive" *trend* statuses indicate a lack of a significant trend and do not reflect trend regression line slopes.

"Inconclusive" *assessment* statuses indicate chlorophyll-a response impairment thresholds were not exceeded, but at least one nutrient screening threshold was exceeded without a response assessment endpoint also being met.

Total Phosphorus Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis	Water Quality Status	Nutrient Criteria	Lake Ecoregion

Total Nitrogen Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis: Slope (Δ µg/L TN per year) / Slope (Δ µg/L TP per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Status: Trend	Water Quality Status: Assessment	Nutrient Criteria	Lake Ecoregion
Atkinson Lake	**7234**	**30**	**-0.001**	**0.050**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Belleview Lake (LaBelle # 2)	7023	11	+0.924	0.640	Inconclusive	Impaired for Chl*a*	NNC	Plains
Bilby Ranch Lake	7368	21	-0.460	0.097	Inconclusive	Inconclusive	NNC	Plains
Blind Pony Lake	7189	26	-1.119	0.058	Inconclusive	Impaired for Chl*a*	NNC	Plains
Blue Springs Lake	7358	29	-0.054	0.778	Inconclusive	Meeting nutrient criteria	NNC	Plains
Brookfield Lake	7138	24	-0.155	0.087	Inconclusive	Meeting nutrient criteria	NNC	Plains
Butler Lake	7229	10	+0.635	0.858	Inconclusive	Impaired for Chl*a*	NNC	Plains
Deer Ridge Community Lake	7015	30	-0.004	1.000	Inconclusive	Impaired for Chl*a*	NNC	Plains
Eagle Lake (Cameron # 3)	**7119**	**22**	**+1.460**	**0.015**	**Degrading**	**Inconclusive**	**NNC**	**Plains**
Grindstone Lake (Cameron # 4)	7384	19	-1.315	0.484	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harrison County Lake	**7386**	**21**	**+1.853**	**0.037**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Harry S. Truman Reservoir	7207	31	+0.043	0.892	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hazel Hill Lake	7387	21	+0.433	0.349	Inconclusive	Impaired for Chl*a*	NNC	Plains
Henry Sever Lake	7024	28	-0.094	0.890	Inconclusive	Inconclusive	NNC	Plains
Higginsville Reservoir South	7190	29	+1.074	0.081	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hunnewell Lake	7029	29	-0.025	0.866	Inconclusive	Inconclusive	NNC	Plains
Kraut Run Lake	7056	25	+0.430	0.441	Inconclusive	Impaired for Chl*a*	NNC	Plains
Lake Jacomo	**7101**	**27**	**-0.389**	**< 0.001**	**Improving**	**Meeting nutrient criteria**	**NNC**	**Plains**
Lake Lotawana	7091	15	-0.017	1.000	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lucern	7248	14	+0.166	0.743	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Saint Louis	7054	24	+0.096	0.751	Inconclusive	Impaired for Chl*a*	NNC	Plains
Lake Sainte Louise	7055	20	+0.143	0.263	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Tapawingo	7103	13	-0.302	0.360	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lamar Lake	7356	22	-0.465	0.535	Inconclusive	Impaired for Chl*a*	NNC	Plains

Total Nitrogen Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ µg/L TN per year)	*p*-value	Trend	Assessment		
Little Dixie Lake	7180	34	+0.130	0.573	Inconclusive	Impaired for Chl*a*	NNC	Plains
Long Branch Lake	**7171**	**25**	**-1.234**	**0.047**	**Improving**	**Inconclusive**	**NNC**	**Plains**
Mark Twain Lake	7033	31	-0.001	0.395	Inconclusive	Inconclusive	NNC	Plains
Monroe City Lake B	7034	17	+0.569	0.202	Inconclusive	Impaired for Chl*a*	NNC	Plains
Mozingo Lake	**7402**	**21**	**+0.897**	**0.003**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Nodaway Lake	7076	21	+0.862	0.057	Inconclusive	Impaired for Chl*a*	NNC	Plains
North Lake	**7218**	**26**	**+2.083**	**0.038**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Old Reservoir (Water Works)	7165	16	+0.201	0.558	Inconclusive	Inconclusive	NNC	Plains
Raintree Lake	7213	29	-0.113	0.666	Inconclusive	Impaired for Chl*a*	NNC	Plains
Rothwell Lake	7164	19	+0.266	0.780	Inconclusive	Inconclusive	NNC	Plains
Smithville Lake	7077	23	-0.476	0.597	Inconclusive	Impaired for Chl*a*	NNC	Plains
Spring Fork Lake	7187	20	+1.196	0.417	Inconclusive	Impaired for Chl*a*	NNC	Plains
Sugar Creek Lake	7166	27	-0.377	0.055	Inconclusive	Inconclusive	NNC	Plains
Tri-City Lake	7624	23	+0.264	0.398	Inconclusive	Inconclusive	NNC	Plains
Unionville New Reservoir	7154	15	+1.879	0.161	Inconclusive	Impaired for Chl*a*	NNC	Plains
Watkins Mill Lake	7087	25	-0.258	0.234	Inconclusive	Meeting nutrient criteria	NNC	Plains
Fellows Lake	**7237**	**29**	**-0.341**	**< 0.001**	**Improving**	**Inconclusive**	**NNC**	**Ozark Highlands**
Hemitite Lake	**7331**	**21**	**+7.279**	**< 0.001**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Ozark Highlands**
Lake of the Ozarks	7205	44	0.000	0.728	Inconclusive	Inconclusive	NNC	Ozark Highlands
Lake Springfield	7312	18	+0.029	0.940	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Lake Wappapello	7336	34	-0.515	0.097	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Little Prairie Lake	**7287**	**27**	**-0.411**	**0.002**	**Improving**	**Inconclusive**	**NNC**	**Ozark Highlands**
McDaniel Lake	7236	25	-0.349	0.053	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Pomme de Terre Lake	7238	30	0.000	0.887	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Stockton Lake	7235	31	0.000	0.817	Inconclusive	Inconclusive	NNC	Ozark Highlands
Binder Lake	7185	24	+0.019	0.941	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Lake Sherwood	7247	12	-0.080	0.837	Inconclusive	Meeting nutrient criteria	NNC	Ozark Border

Total Nitrogen Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis: Slope (Δ µg/L TN per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Status: Trend	Water Quality Status: Assessment	Nutrient Criteria	Lake Ecoregion
Manito Lake	7198	21	-1.345	0.450	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Bowling Green New Lake	7004	26	+0.129	0.441	Inconclusive	Meeting nutrient criteria	SSC	Plains
Bowling Green Old Lake	7003	12	+0.956	0.451	Inconclusive	Impaired for TN, TP	SSC	Plains
Forest Lake	7151	31	-0.073	0.341	Inconclusive	Impaired for Chl*a*	SSC	Plains
Fox Valley Lake	7008	21	+0.439	0.065	Inconclusive	Impaired for Chl*a*, TN, TP	SSC	Plains
Lake Viking	7122	20	-0.061	0.673	Inconclusive	Meeting nutrient criteria	SSC	Plains
Waukomis Lake	**7072**	**18**	**+0.532**	**0.004**	**Degrading**	**Impaired for TP**	**SSC**	**Plains**
Weatherby Lake	7071	25	+0.114	0.107	Inconclusive	Impaired for Chl*a*, TN, TP	SSC	Plains
Clearwater Lake	7326	27	-0.044	0.677	Inconclusive	Impaired for Chl*a*	SSC	Ozark Highlands
Council Bluff Lake	**7299**	**24**	**-0.116**	**0.005**	**Improving**	**Meeting nutrient criteria**	**SSC**	**Ozark Highlands**
Lac Capri	7297	25	-0.049	0.072	Inconclusive	Impaired for TN	SSC	Ozark Highlands
Lac Shayne	**7606**	**25**	**-0.063**	**0.018**	**Improving**	**Meeting nutrient criteria**	**SSC**	**Ozark Highlands**
Lake Wauwanoka	7258	12	+0.030	0.837	Inconclusive	Impaired for TN	SSC	Ozark Border

Notes

Bold rows: significant trend *p*-value (0.05 threshold)

Degrading trend status: trend slopes positive and significant

Improving trend status: trend slopes negative and significant

Δ: delta, change in a parameter

WBID: waterbody identifier

NNC: ecoregional numeric nutrient criteria

SSC: site-specific nutrient criteria

Data normality could not be assumed, thus nonparametric trend analysis was conducted. The Mann-Kendall test with the Thiel-Sen slope was used.

Chl*a*: Chlorophyll-a	Secchi: Secchi transparency	TN: Total nitrogen	TP: Total phosphorus	TSS: Total suspended solids

"Inconclusive" *trend* statuses indicate a lack of a significant trend and do not reflect trend regression line slopes.

"Inconclusive" *assessment* statuses indicate chlorophyll-a response impairment thresholds were not exceeded, but at least one nutrient screening threshold was exceeded without a response assessment endpoint also being met.

Total Suspended Solids Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ mg/L TSS per year)	*p*-value	Trend	Assessment		
Atkinson Lake	7234	30	-0.050	0.621	Inconclusive	Inconclusive	NNC	Plains
Belleview Lake (LaBelle # 2)	7023	11	+0.124	0.711	Inconclusive	Impaired for Chl*a*	NNC	Plains
Bilby Ranch Lake	7368	21	-0.092	0.537	Inconclusive	Inconclusive	NNC	Plains
Blind Pony Lake	7189	26	+0.145	0.322	Inconclusive	Impaired for Chl*a*	NNC	Plains
Blue Springs Lake	7358	29	-0.031	0.173	Inconclusive	Meeting nutrient criteria	NNC	Plains
Brookfield Lake	7138	24	-0.069	0.155	Inconclusive	Meeting nutrient criteria	NNC	Plains
Butler Lake	7229	10	-0.072	0.230	Inconclusive	Impaired for Chl*a*	NNC	Plains
Deer Ridge Community Lake	7015	30	-0.155	0.108	Inconclusive	Impaired for Chl*a*	NNC	Plains
Eagle Lake (Cameron # 3)	7119	22	-0.134	0.363	Inconclusive	Inconclusive	NNC	Plains
Grindstone Lake (Cameron # 4)	7384	19	-0.142	0.343	Inconclusive	Impaired for Chl*a*	NNC	Plains
Harrison County Lake	**7386**	**21**	**+0.334**	**0.020**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Harry S. Truman Reservoir	7207	31	+0.004	0.916	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hazel Hill Lake	7387	21	+0.203	0.150	Inconclusive	Impaired for Chl*a*	NNC	Plains
Henry Sever Lake	7024	28	-0.062	0.401	Inconclusive	Inconclusive	NNC	Plains
Higginsville Reservoir South	7190	29	+0.209	0.080	Inconclusive	Impaired for Chl*a*	NNC	Plains
Hunnewell Lake	7029	29	+0.039	0.427	Inconclusive	Inconclusive	NNC	Plains
Kraut Run Lake	7056	25	-0.003	1.000	Inconclusive	Impaired for Chl*a*	NNC	Plains
Lake Jacomo	7101	27	+0.013	0.385	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lotawana	7091	15	-0.087	0.189	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Lucern	7248	14	+0.153	0.189	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Saint Louis	7054	24	-0.073	0.347	Inconclusive	Impaired for Chl*a*	NNC	Plains
Lake Sainte Louise	7055	20	-0.036	0.294	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lake Tapawingo	7103	13	-0.082	0.537	Inconclusive	Meeting nutrient criteria	NNC	Plains
Lamar Lake	7356	22	-0.012	0.922	Inconclusive	Impaired for Chl*a*	NNC	Plains
Little Dixie Lake	**7180**	**34**	**+0.109**	**0.010**	**Degrading**	**Impaired for Chl*a***	**NNC**	**Plains**
Long Branch Lake	7171	25	-0.015	0.537	Inconclusive	Inconclusive	NNC	Plains
Mark Twain Lake	7033	31	+0.036	0.464	Inconclusive	Inconclusive	NNC	Plains

<u>Total Suspended Solids Trends</u>

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ mg/L TSS per year)	*p*-value	Trend	Assessment		
Monroe City Lake B	7034	17	+0.166	0.452	Inconclusive	Impaired for Chl*a*	NNC	Plains
Mozingo Lake	7402	21	+0.143	0.244	Inconclusive	Impaired for Chl*a*	NNC	Plains
Nodaway Lake	7076	21	-0.023	0.945	Inconclusive	Impaired for Chl*a*	NNC	Plains
North Lake	7218	26	-0.126	0.553	Inconclusive	Impaired for Chl*a*	NNC	Plains
Old Reservoir (Water Works)	7165	16	-0.089	0.276	Inconclusive	Inconclusive	NNC	Plains
Raintree Lake	**7213**	**29**	**-0.172**	**0.034**	**Improving**	**Impaired for Chl*a***	**NNC**	**Plains**
Rothwell Lake	7164	19	-0.037	0.705	Inconclusive	Inconclusive	NNC	Plains
Smithville Lake	7077	23	+0.026	0.398	Inconclusive	Impaired for Chl*a*	NNC	Plains
Spring Fork Lake	7187	20	+0.004	0.945	Inconclusive	Impaired for Chl*a*	NNC	Plains
Sugar Creek Lake	7166	27	+0.043	0.359	Inconclusive	Inconclusive	NNC	Plains
Tri-City Lake	**7624**	**23**	**+0.155**	**0.013**	**Degrading**	**Inconclusive**	**NNC**	**Plains**
Unionville New Reservoir	7154	15	-0.018	1.000	Inconclusive	Impaired for Chl*a*	NNC	Plains
Watkins Mill Lake	7087	25	+0.087	0.537	Inconclusive	Meeting nutrient criteria	NNC	Plains
Fellows Lake	7237	29	+0.017	0.272	Inconclusive	Inconclusive	NNC	Ozark Highlands
Hemitite Lake	**7331**	**21**	**+0.510**	**0.020**	**Improving**	**Impaired for Chl*a***	**NNC**	**Ozark Highlands**
Lake of the Ozarks	7205	44	+0.008	0.609	Inconclusive	Inconclusive	NNC	Ozark Highlands
Lake Springfield	7312	18	-0.100	0.256	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Lake Wappapello	7336	34	+0.061	0.110	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Little Prairie Lake	**7287**	**27**	**-0.139**	**< 0.001**	**Improving**	**Inconclusive**	**NNC**	**Ozark Highlands**
McDaniel Lake	7236	25	+0.067	0.080	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Pomme de Terre Lake	7238	30	-0.014	0.318	Inconclusive	Impaired for Chl*a*	NNC	Ozark Highlands
Stockton Lake	**7235**	**31**	**+0.036**	**0.008**	**Degrading**	**Inconclusive**	**NNC**	**Ozark Highlands**
Binder Lake	7185	24	+0.100	0.110	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Lake Sherwood	7247	12	+0.098	0.837	Inconclusive	Meeting nutrient criteria	NNC	Ozark Border
Manito Lake	7198	21	+0.076	0.373	Inconclusive	Impaired for Chl*a*	NNC	Ozark Border
Bowling Green New Lake	7004	26	-0.009	0.740	Inconclusive	Meeting nutrient criteria	SSC	Plains
Bowling Green Old Lake	7003	12	+0.205	0.436	Inconclusive	Impaired for TN, TP	SSC	Plains

Total Suspended Solids Trends

Lake Name	WBID	# of Data Years	Nonparametric Trend Analysis		Water Quality Status		Nutrient Criteria	Lake Ecoregion
			Slope (Δ mg/L TSS per year)	*p*-value	Trend	Assessment		
Forest Lake	7151	31	+0.027	0.171	Inconclusive	Impaired for Chl*a*	SSC	Plains
Fox Valley Lake	7008	21	+0.010	0.837	Inconclusive	Impaired for Chl*a*, TN, TP	SSC	Plains
Lake Viking	7122	20	-0.014	0.945	Inconclusive	Meeting nutrient criteria	SSC	Plains
Waukomis Lake	7072	18	+0.052	0.077	Inconclusive	Impaired for TP	SSC	Plains
Weatherby Lake	7071	25	+0.036	0.118	Inconclusive	Impaired for Chl*a*, TN, TP	SSC	Plains
Clearwater Lake	**7326**	**27**	**+0.046**	**0.015**	**Degrading**	**Impaired for Chl*a***	**SSC**	**Ozark Highlands**
Council Bluff Lake	7299	24	-0.019	0.276	Inconclusive	Meeting nutrient criteria	SSC	Ozark Highlands
Lac Capri	7297	25	-0.019	0.373	Inconclusive	Impaired for TN	SSC	Ozark Highlands
Lac Shayne	7606	25	-0.011	0.650	Inconclusive	Meeting nutrient criteria	SSC	Ozark Highlands
Lake Wauwanoka	7258	12	+0.046	0.631	Inconclusive	Impaired for TN	SSC	Ozark Border

Notes

Bold rows: significant trend *p*-value (0.05 threshold)	WBID: waterbody identifier
Degrading trend status: trend slopes positive and significant	NNC: ecoregional numeric nutrient criteria
Improving trend status: trend slopes negative and significant	SSC: site-specific nutrient criteria
Δ: delta, change in a parameter	Data normality could not be assumed, thus nonparametric trend analysis was conducted. The Mann-Kendall test with the Thiel-Sen slope was used.

Chl*a*: Chlorophyll-a	Secchi: Secchi transparency	TN: Total nitrogen	TP: Total phosphorus	TSS: Total suspended solids

"Inconclusive" *trend* statuses indicate a lack of a significant trend and do not reflect trend regression line slopes.

"Inconclusive" *assessment* statuses indicate chlorophyll-a response impairment thresholds were not exceeded, but at least one nutrient screening threshold was exceeded without a response assessment endpoint also being met.

Ecoregional Lake Trends: Nutrients and Related Parameters

Parameter	Units	# of Lakes	# of Data Years	Nonparametric Trend Analysis: Slope (Δ parameter unit per year)	Nonparametric Trend Analysis: *p*-value	Water Quality Trend Status	Lake Ecoregion
Chl*a*	**μg/L**	**47**	**33**	**0.159**	**0.019**	**Degrading**	**Plains**
Chl*a*	μg/L	4	25	-0.079	0.657	Inconclusive	Ozark Border
Chl*a*	μg/L	13	25	0.011	0.798	Inconclusive	Ozark Highlands
Secchi	m	47	33	0.001	0.600	Inconclusive	Plains
Secchi	m	4	25	-0.004	0.635	Inconclusive	Ozark Border
Secchi	m	13	25	0.001	0.769	Inconclusive	Ozark Highlands
TN	μg/L	47	33	1.99	0.221	Inconclusive	Plains
TN	μg/L	4	25	3.501	0.150	Inconclusive	Ozark Border
TN	μg/L	13	25	0.763	0.296	Inconclusive	Ozark Highlands
TP	μg/L	47	33	0.058	0.789	Inconclusive	Plains
TP	μg/L	4	25	0.032	0.836	Inconclusive	Ozark Border
TP	μg/L	13	25	-0.07	0.115	Inconclusive	Ozark Highlands
TSS	mg/L	47	33	-0.029	0.092	Inconclusive	Plains
TSS	mg/L	4	25	0.005	0.938	Inconclusive	Ozark Border
TSS	**mg/L**	**13**	**25**	**0.031**	**0.003**	**Degrading**	**Ozark Highlands**

Notes

Bold rows: significant trend *p*-value (0.05 threshold)	WBID: waterbody identification
Δ: delta, change in a parameter	NNC: ecoregional numeric nutrient criteria
Degrading: trend slope positive and significant	SSC: site-specific nutrient criteria
Inconclusive trend status: no significant trend, regardless of trend line slope	Data normality could not be assumed, thus nonparametric trend analysis was conducted. The Mann-Kendall test with the Thiel-Sen slope was used.

Chl*a*: Chlorophyll-a	Secchi: Secchi transparency	TN: Total nitrogen	TP: Total phosphorus	TSS: Total suspended solids

*For Secchi only: A "degrading" trend status is associated with a decreasing slope and "improving" with increasing.

APPENDIX H - LAKE SPECIFIC TROPHIC DATA

Trophic Status Classifications for Individual Lakes in Missouri

Total Chlorophyll (ChlT), Total Nitrogen (TN), Total Phosphorus (TP), and Secchi Transparency (Secchi) are reported as seasonal geometric means. Lakes are organized alphabetically by lake ecoregion.

WBID	Lake Name	Size (acres)	# of Data Years	ChlT (ug/l)	TN (mg/l)	TP (mg/l)	Secchi (m)	Trophic Status
Big River Floodplain								
7416	Agate Lake	211	10	47.93	1.08	0.09	0.79	Eutrophic
7255	Creve Coeur Lake	327	28	47.67	0.88	0.13	0.39	Hypereutrophic
7064	Lake Contrary	291	5	217.43	3.26	0.40	0.18	Hypereutrophic
7067	Lewis & Clark Lake (Sugar Lake)	403	5	159.91	2.52	0.35	0.18	Hypereutrophic
1703	Mallard Lake	59	6	47.41	0.50	0.92	0.10	Eutrophic
Ozark Border								
7489	Alpine Lake	233	15	1.74	0.29	0.01	3.79	Oligotrophic
746	Ashland Lake	14	12	44.40	0.61	1.39	0.11	Hypereutrophic
1828	Bella Vista Lake	43	10	9.13	1.54	0.53	0.03	Mesotrophic
7642	Rudolph Bennitt Lake	47	6	12.59	0.67	0.03	1.45	Eutrophic
7251	Big Lake of Whetstone Creek	25	6	11.25	0.71	0.03	1.11	Eutrophic
7185	Binder Lake	127	35	29.60	0.84	0.06	0.85	Eutrophic
1615	Castlenovo Lake	9	13	5.24	1.82	0.44	0.02	Mesotrophic
7182	D.C. Rogers Lake	195	16	8.95	0.56	0.04	0.96	Eutrophic
7177	Glover Spring Lake	23	7	17.28	0.86	0.06	1.12	Eutrophic
7265	Goose Creek Lake	316	12	4.06	0.40	0.02	2.30	Mesotrophic
7492	Innsbrook Lake	37	13	9.14	0.53	0.03	1.33	Eutrophic
7444	Johnson Lake	14	7	9.54	0.58	0.03	1.42	Eutrophic
7646	Koeneman Park Lake	5	17	33.40	1.09	0.21	0.85	Eutrophic
7267	Lake Anne	81	11	17.26	0.62	0.04	1.36	Eutrophic
7659	Lake Boutin	20	11	10.31	0.59	0.03	1.44	Eutrophic
7247	Lake Eleanor (Sherwood Lakes)	4	12	15.00	0.74	0.04	1.02	Eutrophic
7311	Lake Girardeau	144	16	34.59	0.84	0.05	0.88	Eutrophic
1615	Lake Konstanz	18	15	2.08	2.57	0.34	0.01	Oligotrophic
7247	Lake Sherwood	135	12	6.92	0.51	0.02	1.86	Mesotrophic
7307	Lake Tishomingo	120	21	7.45	0.54	0.03	1.84	Mesotrophic
1632	Lake Walter	7	4	26.61	0.72	0.83	0.05	Eutrophic
7266	Lake Wanda Lee	97	10	17.55	0.58	0.05	1.62	Eutrophic
7258	Lake Wauwanoka	93	23	3.19	0.43	0.01	2.99	Mesotrophic
1632	Lake Whitesell	13	4	23.88	0.86	0.89	0.04	Eutrophic
7198	Manito Lake	77	21	17.38	1.04	0.09	0.61	Eutrophic
7273	Perry County Community Lake	89	14	44.09	1.01	0.09	0.71	Eutrophic
7183	Peters Lake	62	11	19.21	0.79	0.05	0.80	Eutrophic
7249	Pinnacle Lake	115	7	6.09	0.47	0.02	1.90	Mesotrophic
1007	Quarry Heights Lake	1	13	16.48	1.95	0.52	0.04	Mesotrophic
7247	Robin Hood Lake (Sherwood Lakes)	7	12	22.70	0.92	0.06	0.95	Eutrophic
7502	Simpson Park Lake	64	9	40.12	0.78	0.08	0.55	Eutrophic
1008	Stephens Lake	9	12	11.89	1.19	0.63	0.04	Eutrophic
7247	Sugar Hollow Lake (Sherwood Lakes)	16	11	15.79	0.88	0.04	1.06	Eutrophic
7341	Tywappity Community Lake	43	15	45.41	1.13	0.06	0.67	Eutrophic
7647	UMC Dairy Farm Lake # 1	14	14	75.61	1.90	0.15	0.52	Hypereutrophic
1030	UMC Dairy Farm Lake # 3	6	5	46.82	0.57	1.74	0.40	Hypereutrophic
1615	Wanderfern Lake	40	13	7.67	1.68	0.49	0.02	Mesotrophic

WBID	Lake Name	Size (acres)	# of Data Years	ChlT (ug/l)	TN (mg/l)	TP (mg/l)	Secchi (m)	Trophic Status
1632	Wellsville Lake	17	4	3.50	4.26	0.42	0.02	Mesotrophic
1713	Whitecliff Park Lake	1	9	19.86	1.58	0.81	0.04	Eutrophic
7203	Winegar Lake	8	5	9.18	0.59	0.02	1.80	Mesotrophic
1007	Woodrail Lake	11	6	8.59	2.77	0.51	0.03	Mesotrophic
Ozark Highlands								
7239	Austin Community Lake	21	13	9.16	0.63	0.03	1.32	Eutrophic
7186	Ben Branch Lake	37	11	13.03	0.70	0.02	1.54	Mesotrophic
7315	Bull Shoals Lake	9000	18	4.84	0.33	0.01	2.90	Oligotrophic
7326	Clearwater Lake	1635	36	6.44	0.22	0.02	1.60	Mesotrophic
7299	Council Bluff Lake	423	33	2.96	0.22	0.01	3.35	Oligotrophic
7334	Crane Lake	109	10	4.23	0.23	0.02	1.43	Mesotrophic
7237	Fellows Lake	800	36	5.66	0.36	0.02	2.69	Mesotrophic
7324	Fourche Lake	49	15	3.55	0.28	0.01	2.82	Mesotrophic
7328	Fredricktown City Lake	80	15	31.58	0.71	0.06	0.71	Eutrophic
7331	Hemitite Lake	215	22	29.70	0.85	0.07	0.89	Eutrophic
7288	Indian Hills Lake	279	18	15.32	0.63	0.03	1.02	Eutrophic
7297	Lac Capri	106	36	2.13	0.30	0.01	4.67	Oligotrophic
7605	Lac Carmel	55	19	2.69	0.32	0.01	2.99	Oligotrophic
7617	Lac Lafitte	36	4	2.72	0.38	0.01	3.57	Oligotrophic
7614	Lac Marseilles	48	16	2.58	0.34	0.01	3.57	Oligotrophic
7606	Lac Shayne	76	31	1.89	0.27	0.01	3.45	Oligotrophic
7332	Lake Killarney	61	10	30.17	0.63	0.06	0.78	Eutrophic
7206	Lake Niangua	256	4	10.30	0.76	0.06	0.45	Eutrophic
7243	Lake Northwoods	77	13	4.60	0.42	0.02	1.43	Mesotrophic
7205	Lake of the Ozarks	59520	41	13.93	0.56	0.03	1.85	Eutrophic
7312	Lake Springfield	293	24	21.32	1.01	0.06	0.63	Eutrophic
7314	Lake Taneycomo	2119	22	5.74	0.70	0.02	1.65	Mesotrophic
7304	Lake Timberline	39	17	3.86	0.29	0.02	3.53	Mesotrophic
7336	Lake Wappapello	7827	37	26.39	0.65	0.07	1.16	Eutrophic
7287	Little Prairie Lake	95	31	9.64	0.49	0.03	1.41	Eutrophic
7322	Loggers Lake	21	9	4.26	0.20	0.01	3.17	Mesotrophic
7325	Lower Taum Sauk Reservoir	200	19	4.64	0.20	0.02	1.62	Mesotrophic
7319	McCormack Lake	9	7	2.10	0.14	0.01	3.03	Oligotrophic
7236	McDaniel Lake	218	28	16.75	0.47	0.04	1.42	Eutrophic
2795	Miller Community Lake	26	16	8.83	1.39	0.48	0.02	Mesotrophic
7301	Monsanto Lake	18	13	2.44	0.35	0.01	1.73	Mesotrophic
7316	Noblett Lake	26	12	5.24	0.26	0.02	2.45	Mesotrophic
7317	Norfork Lake	1000	8	3.97	0.58	0.02	1.90	Mesotrophic
7241	Peaceful Valley Lake	158	16	18.82	0.77	0.03	1.42	Eutrophic
7406	Pinewoods Lake	22	11	12.24	0.61	0.03	1.29	Eutrophic
7238	Pomme de Terre Lake	7675	36	15.43	0.54	0.03	1.75	Eutrophic
7323	Ripley Lake	18	13	10.52	0.58	0.03	1.79	Eutrophic
7245	Roby Lake	10	11	5.09	0.42	0.02	2.00	Mesotrophic
7333	Shepard Mountain Lake	21	7	14.56	0.41	0.03	1.17	Eutrophic
7321	Sims Valley Community Lake	42	15	11.04	0.44	0.02	1.56	Mesotrophic
7235	Stockton Lake	23680	36	7.34	0.44	0.01	2.78	Mesotrophic
7294	Sunnen Lake	206	15	4.03	0.31	0.02	2.32	Mesotrophic
7313	Table Rock Lake	41747	37	6.59	0.58	0.03	3.14	Mesotrophic
7281	Turner Lake (Shawnee Mac Lakes)	15	12	9.08	0.42	0.02	1.55	Mesotrophic
7282	Ziske Lake (Shawnee Mac Lakes)	28	13	12.48	0.49	0.03	1.59	Eutrophic

WBID	Lake Name	Size (acres)	# of Data Years	ChlT (ug/l)	TN (mg/l)	TP (mg/l)	Secchi (m)	Trophic Status
Plains								
7225	Adrian Reservoir	45	5	24.07	0.91	0.06	0.42	Eutrophic
7360	Amarugia Highlands Lake	39	10	11.24	0.64	0.05	0.99	Eutrophic
1615	Aspen Lake	132	14	7.48	1.65	0.49	0.02	Mesotrophic
7234	Atkinson Lake	434	31	35.37	1.10	0.08	0.52	Eutrophic
7627	August A. Busch Lake # 37	30	6	8.41	0.53	0.03	1.17	Eutrophic
7019	Baring Country Club Lake	85	9	14.42	0.93	0.03	1.17	Eutrophic
7365	Belcher Branch Lake	42	10	14.97	0.57	0.04	1.06	Eutrophic
7023	Belleview Lake (LaBelle # 2)	105	12	47.77	1.33	0.06	0.77	Eutrophic
7368	Bilby Ranch Lake	95	22	28.59	0.89	0.05	1.04	Eutrophic
7189	Blind Pony Lake	96	30	33.52	1.28	0.09	0.52	Eutrophic
7358	Blue Springs Lake	642	29	17.86	0.60	0.05	1.13	Eutrophic
7004	Bowling Green New Lake	41	34	7.85	0.53	0.03	1.64	Mesotrophic
7003	Bowling Green Old Lake	28	12	9.68	0.93	0.07	0.89	Eutrophic
7123	Breckenridge Lake	13	5	13.40	0.68	0.05	1.05	Eutrophic
7138	Brookfield Lake	120	34	7.73	0.61	0.02	1.28	Mesotrophic
7159	Bucklin Lake	17	4	26.82	1.60	0.12	0.54	Hypereutrophic
7232	Bushwacker Lake	148	10	13.94	0.59	0.03	1.05	Eutrophic
7229	Butler Lake	71	9	39.41	1.10	0.08	0.63	Eutrophic
7374	Catclaw Lake	42	5	23.27	1.15	0.11	0.39	Hypereutrophic
7120	Century Lake (Cameron # 1)	25	9	22.63	1.60	0.20	0.37	Hypereutrophic
7058	Charity Lake	9	4	15.59	0.62	0.04	1.28	Eutrophic
7041	Clarence Lake # 1	20	4	19.77	0.83	0.05	0.77	Eutrophic
7196	Clear Fork Lake	16	10	18.14	0.70	0.04	0.90	Eutrophic
7378	Coot Lake	20	7	27.40	1.03	0.06	0.44	Eutrophic
7379	Cottontail Lake	22	10	20.99	0.95	0.09	0.44	Eutrophic
7085	Crystal Lake	122	4	27.85	0.90	0.07	0.58	Eutrophic
7015	Deer Ridge Community Lake	45	38	20.53	0.88	0.05	1.11	Eutrophic
7230	Drexel City Reservoir South	51	5	45.53	1.44	0.09	0.59	Eutrophic
7119	Eagle Lake (Cameron # 3)	92	25	29.84	1.23	0.11	0.52	Hypereutrophic
7026	Edina Reservoir	51	15	23.62	1.47	0.08	0.55	Eutrophic
7192	Edwin A. Pape Lake	273	16	22.25	1.15	0.08	0.55	Eutrophic
7011	Ella Ewing Lake	12	11	26.09	1.23	0.08	0.55	Eutrophic
7146	Elmwood City Lake	197	13	18.00	0.77	0.06	0.72	Eutrophic
7151	Forest Lake	580	37	6.20	0.45	0.03	1.21	Eutrophic
7008	Fox Valley Lake	105	21	12.68	0.74	0.03	1.64	Eutrophic
7643	Foxtail Lake	3	11	20.36	0.81	0.06	0.77	Eutrophic
7426	Garden City Lake # 2	39	5	20.25	0.93	0.05	0.86	Eutrophic
7383	Gopher Lake	38	8	29.95	0.90	0.10	0.46	Eutrophic
7161	Green City Lake	57	11	26.52	1.14	0.08	0.55	Eutrophic
7384	Grindstone Lake (Cameron # 4)	173	22	30.55	2.23	0.18	0.49	Hypereutrophic
7124	Hamilton Lake	80	15	15.28	1.01	0.06	0.81	Eutrophic
7644	Happy Holler Lake	68	4	48.00	1.07	0.07	0.87	Eutrophic
7385	Harmony Mission Lake	96	12	22.49	0.78	0.05	0.90	Eutrophic
7386	Harrison County Lake	280	22	33.61	1.09	0.08	0.65	Eutrophic
7214	Harrisonville City Lake	419	12	19.85	0.89	0.05	0.74	Eutrophic
7207	Harry S. Truman Reservoir	55600	37	18.35	0.77	0.05	1.20	Eutrophic
7152	Hazel Creek Lake	518	16	12.36	0.64	0.02	1.08	Eutrophic
7387	Hazel Hill Lake	62	21	33.68	1.10	0.06	0.66	Eutrophic
7024	Henry Sever Lake	153	36	16.30	0.99	0.05	0.93	Eutrophic

WBID	Lake Name	Size (acres)	# of Data Years	ChlT (ug/l)	TN (mg/l)	TP (mg/l)	Secchi (m)	Trophic Status
7197	Higbee Lake	13	4	9.73	0.65	0.03	1.45	Eutrophic
7190	Higginsville Reservoir South	147	34	27.03	1.36	0.11	0.54	Hypereutrophic
7193	Holden City Lake	290	12	16.12	0.86	0.05	0.67	Eutrophic
7029	Hunnewell Lake	228	35	20.85	0.87	0.05	0.97	Eutrophic
7389	Indian Creek Lake	199	8	15.21	0.68	0.03	1.50	Eutrophic
7391	Jackrabbit Lake	28	6	25.04	0.95	0.11	0.59	Eutrophic
7104	Jamesport City Lake	16	6	53.94	1.34	0.13	0.65	Hypereutrophic
7105	Jamesport Community Lake	27	5	120.51	2.00	0.14	0.39	Hypereutrophic
7114	King City New Reservoir	25	4	21.37	0.97	0.07	0.70	Eutrophic
7113	King City Old Reservoir	12	4	56.12	1.26	0.15	0.42	Hypereutrophic
7112	King Lake	204	9	19.37	1.67	0.20	0.19	Hypereutrophic
7056	Kraut Run Lake	164	26	64.56	1.19	0.11	0.46	Hypereutrophic
7039	La Plata City Lake	89	8	16.71	0.83	0.03	1.01	Eutrophic
7453	Lake Allaman	6	8	14.12	0.64	0.04	1.13	Eutrophic
7469	Lake Buteo	7	10	6.73	0.58	0.03	1.23	Eutrophic
7101	Lake Jacomo	998	32	15.93	0.54	0.03	1.33	Eutrophic
7049	Lake Lincoln	51	34	6.40	0.43	0.02	2.07	Mesotrophic
7091	Lake Lotawana	487	23	15.52	0.57	0.04	1.34	Eutrophic
7248	Lake Lucern	43	15	8.60	0.57	0.03	1.34	Eutrophic
7131	Lake Marie	60	12	5.46	0.47	0.02	2.64	Mesotrophic
7158	Lake Nehai Tonkayea	228	14	2.82	0.39	0.01	2.42	Mesotrophic
7403	Lake Nell	26	7	33.98	1.10	0.10	0.46	Eutrophic
7629	Lake of the Woods KC	7	10	43.01	0.97	0.11	0.48	Hypereutrophic
7132	Lake Paho	273	18	13.41	0.90	0.05	0.67	Eutrophic
7054	Lake Saint Louis	444	25	23.58	1.00	0.07	0.54	Eutrophic
7055	Lake Sainte Louise	71	21	10.82	0.53	0.03	1.22	Eutrophic
7103	Lake Tapawingo	83	21	23.40	0.70	0.04	1.05	Eutrophic
7631	Lake Tebo	73	7	6.80	0.62	0.02	1.92	Mesotrophic
7153	Lake Thunderhead	859	14	14.63	0.91	0.05	0.70	Eutrophic
7122	Lake Viking	552	28	9.27	0.52	0.03	1.45	Eutrophic
7212	Lake Winnebago	272	13	17.66	0.85	0.05	0.82	Eutrophic
7356	Lamar Lake	148	28	41.24	1.20	0.09	0.77	Eutrophic
7018	Lancaster City New Lake	56	8	31.91	0.97	0.07	0.70	Eutrophic
7082	Lawson City Lake	25	7	20.59	0.91	0.03	0.95	Eutrophic
7111	Limpp Community Lake	27	5	68.30	1.50	0.11	0.39	Hypereutrophic
7143	Linneus Lake	17	4	18.17	0.97	0.07	0.66	Eutrophic
7180	Little Dixie Lake	199	39	28.29	0.92	0.06	0.71	Eutrophic
7209	Lone Jack Lake	31	4	17.08	0.68	0.03	1.62	Eutrophic
7171	Long Branch Lake	2686	34	13.57	0.95	0.06	0.66	Eutrophic
7097	Longview Lake	953	27	10.31	0.66	0.04	0.93	Eutrophic
7168	Macon City Lake	189	14	23.99	0.90	0.05	0.70	Eutrophic
7398	Maple Leaf Lake	127	12	22.28	0.85	0.04	1.01	Eutrophic
7136	Marceline New City Lake	160	16	25.81	1.02	0.07	1.12	Eutrophic
7033	Mark Twain Lake	20100	33	16.58	1.29	0.08	1.06	Eutrophic
7115	Maysville Lake	27	12	39.40	1.29	0.16	0.56	Hypereutrophic
713	McCredie Watershed W-1 Reservoir	13	4	71.89	0.56	1.80	0.12	Hypereutrophic
7014	Memphis Lake (Lake Showme)	253	8	15.34	0.79	0.03	1.69	Eutrophic
7013	Memphis Reservoir	41	14	44.48	1.32	0.08	0.53	Eutrophic
7144	Milan Lake North	13	5	33.35	1.01	0.06	1.14	Eutrophic
7439	Milan Lake South	37	12	12.80	0.69	0.05	0.85	Eutrophic
7031	Monroe City Lake	94	9	37.67	1.27	0.10	0.66	Eutrophic

WBID	Lake Name	Size (acres)	# of Data Years	ChlT (ug/l)	TN (mg/l)	TP (mg/l)	Secchi (m)	Trophic Status
7034	Monroe City Lake B	60	20	33.15	1.21	0.08	0.49	Eutrophic
7645	Monte Gurwit Lake	11	13	10.47	0.63	0.03	1.43	Eutrophic
7208	Montrose Lake	1444	16	56.23	1.18	0.17	0.31	Hypereutrophic
7402	Mozingo Lake	998	21	18.57	0.83	0.04	1.27	Eutrophic
7076	Nodaway Lake	73	24	26.93	1.10	0.05	0.82	Eutrophic
7109	North Bethany New City Lake	78	17	7.36	0.65	0.03	1.80	Eutrophic
7218	North Lake	38	34	45.92	1.18	0.12	0.62	Hypereutrophic
7093	Odessa Lake	87	8	22.33	0.92	0.05	1.02	Eutrophic
7106	Old Bethany City Lake	18	6	6.75	0.65	0.03	1.78	Eutrophic
7160	Old Marceline City Reservoir	68	8	32.52	1.29	0.12	0.59	Hypereutrophic
7165	Old Reservoir (Water Works)	20	17	19.03	0.78	0.05	1.09	Eutrophic
226	Penn Valley Park Lake	2	5	31.70	0.51	1.16	0.10	Eutrophic
7628	Perry Phillips Lake	41	12	13.47	0.66	0.04	0.87	Eutrophic
7443	Pike Lake	17	5	14.75	0.70	0.03	1.72	Eutrophic
7118	Pony Express Lake	256	19	27.79	0.98	0.06	0.68	Eutrophic
7102	Prairie Lee Lake	144	17	21.55	0.89	0.05	0.85	Eutrophic
7213	Raintree Lake	248	34	16.57	0.91	0.07	0.70	Eutrophic
7083	Ray County Community Lake	23	7	115.22	1.96	0.16	0.38	Hypereutrophic
1615	Red Fox Lake	2	12	13.95	0.80	0.74	0.05	Eutrophic
7070	Riss Lake	134	7	4.07	0.35	0.01	1.76	Mesotrophic
7200	Rocky Fork Lake	60	10	9.14	0.52	0.03	1.93	Eutrophic
7086	Rocky Hollow Lake	20	11	32.80	0.96	0.09	0.54	Eutrophic
7164	Rothwell Lake	25	19	29.48	0.88	0.05	1.09	Eutrophic
1615	Saint Gallen Lake	25	5	5.68	1.58	0.45	0.02	Mesotrophic
7170	Salisbury City Lake (Pine Ridge Lake)	25	4	18.09	0.97	0.05	1.08	Eutrophic
7650	Santa Fe Lake	29	5	19.09	0.86	0.04	1.31	Eutrophic
7061	Savannah City Reservoir	20	5	21.90	0.86	0.05	1.02	Eutrophic
7145	Sears Community Lake	32	5	8.27	0.67	0.03	1.36	Eutrophic
7042	Shelbina Lake	52	15	36.41	1.10	0.10	0.55	Eutrophic
7036	Shelbyville Lake	32	4	88.16	1.66	0.21	0.29	Hypereutrophic
7077	Smithville Lake	7738	31	18.72	0.89	0.04	1.00	Eutrophic
7187	Spring Fork Lake	178	23	47.54	1.27	0.16	0.57	Hypereutrophic
7150	Spring Lake	87	14	6.94	0.54	0.03	1.72	Mesotrophic
7149	Sterling Price Community Lake	23	11	50.21	1.31	0.10	0.59	Eutrophic
7166	Sugar Creek Lake	308	35	20.83	0.81	0.05	0.83	Eutrophic
7121	Sunrise Lake (Cameron # 2)	31	9	29.13	1.24	0.08	0.67	Eutrophic
7173	Thomas Hill Reservoir	4400	19	14.12	0.78	0.06	0.55	Eutrophic
7450	Tobacco Hills Lake	16	4	9.23	0.61	0.03	1.81	Eutrophic
7624	Tri-City Lake	27	30	23.85	1.00	0.05	0.83	Eutrophic
226	Troost Lake	3	5	32.49	0.46	1.45	0.09	Eutrophic
7154	Unionville New Reservoir	74	21	33.57	1.26	0.11	0.50	Hypereutrophic
7051	Vandalia Community Lake	35	18	34.38	1.09	0.07	0.70	Eutrophic
7032	Vandalia Reservoir	28	7	21.57	1.24	0.10	0.79	Hypereutrophic
7087	Watkins Mill Lake	87	31	18.48	0.65	0.04	0.89	Eutrophic
7072	Waukomis Lake	76	28	9.50	0.54	0.03	1.57	Eutrophic
7071	Weatherby Lake	185	26	6.38	0.44	0.02	2.02	Mesotrophic
1615	Whippoorwill Lake	7	13	3.82	1.65	0.46	0.02	Mesotrophic
7050	Whiteside Lake	23	7	10.85	0.73	0.02	1.87	Mesotrophic
7438	Willow Brook Lake	53	6	36.29	1.20	0.09	0.59	Eutrophic
7110	Worth County Community Lake	17	5	32.17	1.27	0.07	0.67	Eutrophic

APPENDIX I - OTHER WATERS RATED AS IMPAIRED AND BELIEVED TO BE IMPAIRED CATEGORY 4A, 4B, & 4C WATERS

WBID	Waterbody Name	Size	Cause of Impairment	Potential Source	Category
3980	Bens Branch	5.8	Cadmium	Mill tailings	4A
3980	Bens Branch	5.8	Lead	Mill tailings	4A
3980	Bens Branch	5.8	Zinc	Mill tailings	4A
1746	Big Bottom Cr.	1.5	Ammonia, Total	Municipal point source discharges	4A
1746	Big Bottom Cr.	1.5	Oxygen, Dissolved	Municipal point source discharges	4A
2074	Big R.	55.6	Lead	Mill tailings	4A
3250	Big Sugar Cr.	39.3	Nutrient/Eutrophication Biol. Indicators	Municipal point source discharges	4A
3250	Big Sugar Cr.	39.3	Nutrient/Eutrophication Biol. Indicators	Nonpoint source	4A
111	Black Cr.	19.4	Escherichia Coli	Municipal point source discharges	4A
3269	Buffalo Cr.	10.7	Nutrient/Eutrophication Biol. Indicators	Municipal point source discharges	4A
3269	Buffalo Cr.	10.7	Nutrient/Eutrophication Biol. Indicators	Nonpoint source	4A
3941	Cave Spring Branch	4.4	Nitrogen, Total	Industrial point source discharge	4A
5003	Center Creek Tributary	2.7	Cadmium	Mill tailings	4A
5003	Center Creek Tributary	2.7	Lead	Mill tailings	4A
5003	Center Creek Tributary	2.7	Zinc	Mill tailings	4A
640	Chariton R.	111.0	Escherichia Coli	Agriculture	4A
3168	Chat Creek	4.7	Zinc	Subsurface, hardrock, mining	4A
2168	Flat River	10.0	Lead	Mill tailings	4A
2168	Flat River	10.0	Lead	Mine tailings	4A
2168	Flat River	10.0	Sedimentation/Siltation	Mill tailings	4A
2168	Flat River	10.0	Zinc	Mill tailings	4A
3256	Indian Cr.	30.8	Nutrient/Eutrophication Biol. Indicators	Municipal point source discharges	4A
3256	Indian Cr.	30.8	Nutrient/Eutrophication Biol. Indicators	Nonpoint source	4A
2681	Jacks Fk.	61.6	Escherichia Coli	Municipal point source discharges	4A
2681	Jacks Fk.	61.6	Escherichia Coli	Other recreational pollution sources	4A
3233	Joyce Cr.	4.5	Escherichia Coli	Nonpoint source	4A
3279	L. Lost Cr.	5.8	Escherichia Coli	Nonpoint source	4A
623	L. Medicine Cr.	39.8	Escherichia Coli	Nonpoint source	4A
1381	L. Sac R.	37.0	Escherichia Coli	Agriculture	4A
1381	L. Sac R.	37.0	Escherichia Coli	Nonpoint source	4A
3249	L. Sugar Cr.	13.2	Nutrient/Eutrophication Biol. Indicators	Municipal point source discharges	4A
3249	L. Sugar Cr.	13.2	Nutrient/Eutrophication Biol. Indicators	Nonpoint source	4A
7314	Lake Taneycomo	2118.6	Dissolved Oxygen Saturation	Dam or impoundment	4A
7356	Lamar Lake	148.0	Nutrient/Eutrophication Biol. Indicators	Nonpoint source	4A
857	Long Br.	6.0	Cause Unknown	Source unknown	4A
3278	Lost Cr.	8.5	Escherichia Coli	Nonpoint source	4A
1709	Maline Creek	7.2	Escherichia Coli	Urban runoff/storm sewers	4A
7236	Mcdaniel Lake	218.0	Chlorophyll-A	Nonpoint source	4A
2787	Mckenzie Cr.	4.7	pH	Municipal point source discharges	4A
2787	Mckenzie Cr.	4.7	pH	Source unknown	4A
619	Medicine Cr.	43.8	Escherichia Coli	Nonpoint source	4A
1284	Middle Fk. Tebo Cr.	7.5	Total Dissolved Solids	Coal mining	4A
1707	Mississippi R.	44.6	Lead	Industrial point source discharge	4A

WBID	Waterbody Name	Size	Cause of Impairment	Potential Source	Category
1707	Mississippi R.	44.6	Zinc	Industrial point source discharge	4A
1234	Monegaw Cr.	18.4	Sulfates	Coal mining	4A
1300	Mound Br.	8.9	Dissolved Oxygen Saturation	Source unknown	4A
674	Mussel Fk.	29.0	Escherichia Coli	Nonpoint source	4A
1170	Niangua R.	56.0	Escherichia Coli	Nonpoint source	4A
279	Nodaway R.	59.3	Escherichia Coli	Nonpoint source	4A
3268	Patterson Cr.	3.5	Nutrient/Eutrophication Biol. Indicators	Municipal point source discharges	4A
3268	Patterson Cr.	3.5	Nutrient/Eutrophication Biol. Indicators	Nonpoint source	4A
1444	Piper Cr.	5.3	Aquatic Macroinvertebrate Bioassessments	Source unknown	4A
3232	Pogue Cr.	2.5	Escherichia Coli	Nonpoint source	4A
2128	Pond Cr.	1.0	Sedimentation/Siltation	Mill tailings	4A
2128	Pond Cr.	1.0	Zinc	Mill tailings	4A
1249	S. Grand R.	66.8	Escherichia Coli	Nonpoint source	4A
3940	Scoggins Branch	1.6	Cadmium	Industrial/commercial stormwater discharge, permitted	4A
3940	Scoggins Branch	1.6	Zinc	Industrial/commercial stormwater discharge, permitted	4A
2170	Shaw Br.	1.2	Lead	Mill tailings	4A
2119	Shibboleth Br.	1.0	Lead	Mill tailings	4A
2119	Shibboleth Br.	1.0	Zinc	Mill tailings	4A
2120	Shibboleth Br.	3.0	Lead	Mill tailings	4A
2120	Shibboleth Br.	3.0	Zinc	Mill tailings	4A
3230	Shoal Creek	15.7	Escherichia Coli	Nonpoint source	4A
3231	Shoal Creek	7.4	Escherichia Coli	Nonpoint source	4A
1870	Spring Cr.	18.0	Oxygen, Dissolved	Municipal point source discharges	4A
1870	Spring Cr.	18.0	Solids, Suspended/Bedload	Municipal point source discharges	4A
7187	Spring Fork Lake	178.0	Chlorophyll-A	Nonpoint source	4A
710	Stinson Cr.	11.9	Oxygen, Dissolved	Municipal point source discharges	4A
710	Stinson Cr.	11.9	Oxygen, Dissolved	Natural conditions	4A
549	Thompson R.	70.6	Escherichia Coli	Nonpoint source	4A
3822	Town Br.	2.5	Cause Unknown	Source unknown	4A
1288	Trib. M. Fk. Tebo Cr.	3.1	pH	Coal mining	4A
1288	Trib. M. Fk. Tebo Cr.	3.1	Total Dissolved Solids	Coal mining	4A
1225	Trib. to Big Otter Cr.	1.0	pH	Coal mining	4A
1420	Trib. to Goose Cr.	3.0	Escherichia Coli	Nonpoint source	4A
3663	Trib. to Indian Cr.	0.3	Lead	Subsurface, hardrock, mining	4A
1414	Turnback Cr.	19.9	Escherichia Coli	Nonpoint source	4A
2863	Village Cr.	1.9	Sedimentation/Siltation	Mill tailings	4A
400	W. Fk. Sni-A-Bar Cr.	9.0	Oxygen, Dissolved	Municipal point source discharges	4A
400	W. Fk. Sni-A-Bar Cr.	9.0	Oxygen, Dissolved	Source unknown	4A
560	Weldon R.	43.4	Escherichia Coli	Nonpoint source	4A
7009	Wyaconda Lake	9.0	Atrazine	Agriculture	4A
1145	Dry Auglaize Cr.	7.6	Cause Unknown	Source unknown	4B
1145	Dry Auglaize Cr.	7.6	Oxygen, Dissolved	Source unknown	4B
883	Gabriel Cr.	13.6	Oxygen, Dissolved	Municipal point source discharges	4B
2786	Mckenzie Cr.	6.3	Oxygen, Dissolved	Municipal point source discharges	4B

WBID	Waterbody Name	Size	Cause of Impairment	Potential Source	Category
1842	Fox Cr.	7.2	Aquatic Macroinvertebrate Bioassessments	Source unknown	4C
2660	Gladden Cr.	2.5	Oxygen, Dissolved	Natural conditions	4C
430	Grand R.	127.5	Fishes Bioassessments	Channelization	4C
3413	Horseshoe Cr.	5.8	Oxygen, Dissolved	Drought-related impacts	4C
56	N. Fabius R.	92.0	Habitat Assessment, Streams	Channelization	4C
1031	Osage R.	81.9	Aquatic Macroinvertebrate Bioassessments	Dam or impoundment	4C
1387	Pea Ridge Cr.	1.5	Aquatic Macroinvertebrate Bioassessments	Source unknown	4C
216	Peruque Cr.	10.3	Cause Unknown	Dam or impoundment	4C
71	S. Fabius R.	80.6	Fishes Bioassessments	Channelization	4C
91	Salt R.	29.0	Oxygen, Dissolved	Flow regulation/ modification impacts	4C
2755	W. Fk. Black R.	32.3	Physical Substrate Habitat Alterations	Habitat modification (other than hydromodification)	4C

APPENDIX J - POTENTIALLY IMPAIRED WATERS
CATEGORY 2B & 3B WATERS

WBID	Waterbody Name	Size	Concern	Category
1799	Apple Cr.	44.8	Invertebrate Community	2B
1383	Asher Cr.	8.7	Bacteria	2B
1384	Asher Cr.	4.0	Bacteria	2B
7234	Atkinson Lake	434.0	Nutrients	2B
2760	Bee Fk.	8.7	Heavy Metals	2B
3966	Bee Fork	5.9	Heavy Metals	2B
1250	Big Cr.	70.5	Low Dissolved Oxygen	2B
7251	Big Lake	25.0	Nutrients	2B
7368	Bilby Ranch Lake	95.0	Nutrients	2B
891	Blackwater R.	79.4	Aquatic Habitat	2B
421	Blue R.	12.0	Bacteria	2B
7370	Bluestem Lake	13.0	Nutrients	2B
32	Bobs Cr.	1.7	Nutrients	2B
1844	Brush Cr.	2.5	Bacteria	2B
7159	Bucklin Lake	17.0	Nutrients	2B
2422	Bull Cr.	5.0	Temperature	2B
2423	Bull Cr.	18.9	Low Dissolved Oxygen	2B
7246	Callaway Lake	135.0	Nutrients	2B
7119	Cameron Lake #3	92.0	Nutrients	2B
322	Castile Cr.	40.2	Low Dissolved Oxygen	2B
3225	Cedar Cr.	2.2	Sediment	2B
7040	Clarence Lake #2	31.0	Nutrients	2B
1336	Clear Cr.	22.3	Low Dissolved Oxygen	2B
132	Coon Cr.	11.8	Low Dissolved Oxygen	2B
2177	Coonville Cr.	1.3	Heavy Metals	2B
1943	Courtois Cr.	32.0	Heavy Metals	2B
1928	Crooked Creek	3.5	Heavy Metals	2B
7661	Daniel Boone Lake	288.0	Nutrients	2B
690	Dark Cr.	9.1	Sulfate	2B
2991	Ditch #2	4.9	Low Dissolved Oxygen	2B
1180	Dousinbury Cr.	3.9	Low Dissolved Oxygen	2B
1866	Dry Fk.	27.0	Invertebrate Community	2B
3178	Dry Fk.	3.4	Invertebrate Community	2B
1314	Dry Wood Cr.	29.9	Sulfate	2B
398	E. Fk. Shoal Cr.	2.9	Aquatic Habitat	2B
1265	East Cr.	9.4	High Conductivity, Low Dissolved Oxygen	2B
4120	Fenton Creek Tributary	1.5	Bacteria	2B
7201	Finger Lakes	118.0	Fish Community	2B

WBID	Waterbody Name	Size	Concern	Category
394	Fishing R.	8.5	Bacteria	2B
1419	Goose Cr.	4.0	Bacteria	2B
3912	Grand Glaize Creek	0.4	Chloride	2B
3204	Grove Cr.	2.9	Fish And Invertebrate Community	2B
7385	Harmony Mission Lake	96.0	Nutrients	2B
7024	Henry Sever Lake	153.0	Nutrients	2B
596	Hickory Br.	6.8	Nutrients, Low Dissolved Oxygen	2B
3425	Hogan Fk.	5.8	Low Dissolved Oxygen	2B
1351	Horse Cr.	34.6	Low Dissolved Oxygen	2B
212	Indian Camp Cr.	3.5	Sedimentation	2B
1946	Indian Cr.	1.9	Heavy Metals	2B
1719	Joachim Creek	30.0	Heavy Metals	2B
7114	King City New Reservoir	25.4	Nutrients	2B
7039	La Plata City Lake	89.0	Nutrients	2B
7617	Lac Lafitte	36.0	Nutrients	2B
7206	Lake Niangua	256.0	Nutrients, Turbidity	2B
7153	Lake Thunderhead	859.0	Atrazine, Nurients	2B
7018	Lancaster City Lake - New	56.0	Temperature, Nutrients	2B
7067	Lewis & Clark Lake	403.0	Fish Community	2B
7143	Linneus Lake	17.0	Nutrients	2B
3852	Little Saint Francis River	13.4	Sediment, Invertebrate Community	2B
2763	Logan Cr.	36.0	Invertebrate Community	2B
7171	Long Branch Lake	2686.0	Nutrients	2B
7254	Lost Valley Lake	37.0	Nutrients	2B
691	M. Fk. Little Chariton R.	31.5	Heavy Metals	2B
3026	Main Ditch	11.9	Invertebrate Community	2B
3031	Main Ditch #8	18.3	Invertebrate Community	2B
742	Manacle Cr.	2.4	PH, Sulfate , High Conductivity	2B
1308	Marmaton R.	35.7	Bacteria	2B
7115	Maysville Lake	27.0	Nutrients	2B
213	Mccoy Cr.	1.9	Nutrients	2B
1841	Meramec R.	76.0	Fish Community	2B
2183	Meramec R.	22.8	Heavy Metals	2B
2185	Meramec R.	15.7	Heavy Metals, Chloride	2B
7439	Milan Lake South	37.0	Nutrients	2B
159	Mill Cr.	5.0	Invertebrate Community	2B
2118	Mill Cr.	13.5	Heavy Metals	2B
1707	Mississippi R.	28.3	Bacteria	2B
1604	Missouri R.	104.5	Fish Community	2B
426	Mouse Cr.	1.5	Low Dissolved Oxygen	2B

WBID	Waterbody Name	Size	Concern	Category
670	Mussel Fork Cr.	58.0	Low Dissolved Oxygen	2B
2752	Neals Cr.	3.2	Heavy Metals	2B
7022	New La Belle Lake	18.0	Nutrients	2B
1169	Niangua R.	6.0	Aquatic Habitat	2B
7093	Odessa Lake	87.0	pH	2B
7041	Old Lake	20.0	Nutrients	2B
2111	Old Mines Cr.	6.6	Heavy Metals	2B
7165	Old Reservoir	20.0	Nutrients	2B
7441	Palmer Lake	102.0	Nutrients	2B
7183	Peters Lake	62.0	Nutrients	2B
7406	Pinewoods Lake	22.0	Nutrients	2B
1728	Plattin Cr.	19.9	Nutrients	2B
2127	Pond Cr.	1.3	Heavy Metals	2B
7102	Prairie Lee Lake	144.0	Nutrients	2B
884	Richland Cr.	10.0	Invertebrate Community	2B
7323	Ripley Lake	18.0	Temperature, Low Dissolved Oxygen	2B
3326	Rocky Br.	3.2	Bacteria	2B
7200	Rocky Fork Lake	60.0	Nutrients	2B
655	S. Blackbird Cr.	13.0	Bacteria	2B
921	S. Fk. Blackwater R.	5.7	Aquatic Habitat	2B
141	S. Fk. Salt R.	9.3	pH	2B
2835	Saint Francis River	89.3	Chloride	2B
7650	Santa Fe Lake	29.0	Nutrients	2B
7061	Savannah City Reservoir	20.0	Nutrients	2B
1319	Second Nicolson Cr.	4.5	Sulfate	2B
860	Sewer Branch	6.6	Low Dissolved Oxygen	2B
3956	Shady Grove Creek	1.9	Bacteria	2B
397	Shoal Cr.	10.6	Low Dissolved Oxygen, Aquatic Habitat	2B
7321	Sims Valley Community Lake	42.0	Low Dissolved Oxygen	2B
3	South R.	16.3	Nutrients	2B
7235	Stockton Lake	23680.0	Nutrients	2B
958	Straight Fk.	12.0	Invertebrate Community	2B
2751	Strother Creek	6.0	Heavy Metals	2B
3965	Strother Creek	7.2	Heavy Metals	2B
242	Tarkio R.	33.5	Aquatic Habitat	2B
7045	Teal Lake	84.0	Fish Community	2B
3130	Tenmile Pond	5.1	Nutrients	2B
133	Trib. To Coon Cr.	2.0	Nutrients	2B
2115	Trib. To Mineral Fk.	2.0	Heavy Metals	2B
7624	Tri-City Lake	27.0	Nutrients	2B

WBID	Waterbody Name	Size	Concern	Category
2864	Village Cr.	3.0	Heavy Metals	2B
177	W. Fk. Cuivre R.	42.4	Invertebrate Community	2B
3310	W. Fk. East Cr.	4.8	Low Dissolved Oxygen	2B
1339	Walnut Cr.	2.3	Low Dissolved Oxygen, Nutrients	2B
7137	Walt Disney Lake	19.0	Chloride, Sulfate	2B
7087	Watkins Mill Lake	87.0	Bacteria	2B
7110	Worth County Community Lake	17.0	Nutrients	2B
47	Wyaconda R.	42.2	Bacteria	2B
7225	Adrian Reservoir	45.0	Nutrients, Turbidity	3B
334	Agee Cr.	4.8	Aquatic Habitat	3B
2093	Allen Br.	1.8	Fish Community	3B
282	Arapahoe Cr.	8.0	Aquatic Habitat	3B
2880	Back Cr.	3.8	Low Dissolved Oxygen	3B
1209	Barker Cr.	15.0	pH	3B
2103	Bates Cr.	3.2	Invertebrate Community	3B
7068	Bean Lake	420.0	Fish Community	3B
272	Bear Cr.	9.8	Aquatic Habitat	3B
416	Bear Cr.	4.5	Aquatic Habitat	3B
933	Bear Cr.	9.3	Low Dissolved Oxygen, Nutrients	3B
1015	Bear Cr.	6.0	Fish Community	3B
1220	Bear Cr.	7.4	High Conductivity	3B
3265	Beaver Br.	2.0	Invertebrate Community	3B
3266	Beaver Br.	3.5	Invertebrate Community	3B
3267	Beaver Br.	1.5	Invertebrate Community	3B
1509	Beaver Cr.	5.7	Fish Community	3B
273	Bee Cr.	29.4	Aquatic Habitat	3B
3967	Bee Fork Tributary	0.5	Heavy Metals	3B
220	Belleau Cr.	5.1	Failed Toxicity Tests, High Conductivity	3B
2564	Bennetts Bayou	5.3	Invertebrate Community	3B
1608	Bigelow's Cr.	5.0	Low Dissolved Oxygen	3B
993	Blythes Cr.	6.9	Nutrients	3B
1782	Bois Brule Ditch	4.7	Low Dissolved Oxygen	3B
3755	Bourne Cr.	1.9	Aquatic Habitat	3B
1983	Brazil Cr.	13.9	Invertebrate Community	3B
635	Bridge Cr.	1.7	Aquatic Habitat	3B
276	Brush Cr.	7.4	Aquatic Habitat	3B
408	Brush Cr.	5.9	Aquatic Habitat	3B
2056	Brush Cr.	2.0	Fish Community	3B
336	Brushy Cr.	12.1	Aquatic Habitat	3B
377	Brushy Cr.	7.0	Aquatic Habitat	3B

WBID	Waterbody Name	Size	Concern	Category
395	Brushy Cr.	2.2	Aquatic Habitat	3B
2478	Brushy Cr.	6.4	Aquatic Habitat	3B
4068	Buck Branch Tributary	2.2	Aquatic Habitat	3B
3276	Buffalo Creek	4.5	Invertebrate Community, Bacteria	3B
4036	Buffalo Creek Tributary	0.3	Invertebrate Community	3B
3264	Bullskin Cr.	4.9	Fish Community, Bacteria	3B
4008	Bullskin Creek	2.4	Fish Community	3B
4009	Bullskin Creek Tributary	1.4	Nutrients	3B
363	Burr Oak Cr.	2.0	Aquatic Habitat	3B
1195	Cahoochie Cr.	4.0	Limited Data	3B
2431	Camp Cr.	1.0	Fish Community	3B
2833	Cane Cr.	9.8	Low Dissolved Oxygen	3B
2560	Caney Cr.	7.0	Fish Community	3B
389	Carroll Cr.	9.4	Aquatic Habitat	3B
292	Clear Cr.	13.0	Aquatic Habitat	3B
388	Clear Cr.	5.0	Aquatic Habitat	3B
2082	Clear Cr.	4.4	Fish Community	3B
390	Clear Creek	16.6	Aquatic Habitat	3B
225	Cole Cr.	5.7	Chloride, Aquatic Habitat	3B
269	Contrary Cr.	10.0	Fish Community	3B
1459	Contrary Cr.	4.5	Fish Community	3B
410	Cottonwood Cr.	3.9	Aquatic Habitat	3B
1947	Courtois Cr.	1.7	Invertebrate Community	3B
247	Cow Br.	4.4	Aquatic Habitat	3B
330	Crooked Cr.	2.8	Aquatic Habitat	3B
333	Crooked Cr.	4.0	Aquatic Habitat	3B
371	Crooked R.	58.1	Fish Community	3B
376	Crooked R.	7.5	Aquatic Habitat	3B
7085	Crystal Lake	122.0	Nutrients	3B
2616	Cypress Ditch #1	9.7	Invertebrate Community	3B
7182	D C Rogers Lake	195.0	Nutrients	3B
144	Davis Cr.	8.8	Low Dissolved Oxygen	3B
255	Davis Cr.	3.5	Aquatic Habitat	3B
253	Davis Cr. Ditch	6.7	Aquatic Habitat	3B
1215	Deepwater Cr.	9.8	Low Dissolved Oxygen	3B
320	Dicks Cr.	7.3	Aquatic Habitat	3B
268	Dillon Cr.	4.8	Invertebrate Community	3B
3139	Ditch #10	2.7	Low Dissolved Oxygen	3B
3813	Ditch #16	11.2	Low Dissolved Oxygen, Nutrients	3B
2617	Ditch #2	3.2	Low Dissolved Oxygen	3B

WBID	Waterbody Name	Size	Concern	Category
3062	Ditch #24	12.0	Fish Community	3B
2077	Ditch Cr.	1.8	Fish Community	3B
2776	Ditch To Black R.	10.7	Aquatic Habitat	3B
3418	Dry Cr.	9.3	Fish Community	3B
1862	Dry Fk.	23.3	Invertebrate Community	3B
288	E. Br. Elkhorn Cr.	4.7	Aquatic Habitat	3B
257	E. Br. Squaw Cr.	4.2	Aquatic Habitat	3B
373	E. Fk. Crooked R.	6.4	Aquatic Habitat	3B
386	E. Fk. Fishing R.	12.9	Invertebrate Community	3B
249	E. Fk. L. Tarkio Cr.	17.8	Aquatic Habitat	3B
932	E. Fk. Postoak Cr.	12.2	Aquatic Habitat	3B
402	E. Fk. Sni-A-Bar Cr.	9.6	Aquatic Habitat	3B
2085	Ebo Cr.	1.6	Fish Community	3B
414	Edmondson Cr.	1.9	Aquatic Habitat	3B
287	Elkhorn Cr.	11.8	Invertebrate Community	3B
331	Elm Grove Br.	4.2	Aquatic Habitat	3B
3370	Fassnight Cr.	2.8	Invertebrate Community	3B
1705	Fee Fee Cr. (Old)	1.0	Bacteria, Chloride	3B
1607	Femme Osage Cr.	2.0	Fish Community	3B
4119	Fenton Creek Tributary	1.1	Aquatic Habitat	3B
375	Fire Br.	5.4	Aquatic Habitat	3B
318	First Cr.	4.7	Bacteria	3B
1885	Fishwater Cr.	4.8	Low Dissolved Oxygen	3B
289	Florida Cr.	8.4	Aquatic Habitat	3B
3942	Foster Branch	2.5	Low Dissolved Oxygen	3B
1740	Fourche A Duclos Cr.	8.2	Low Dissolved Oxygen	3B
3757	Galligher Cr.	0.2	Low Dissolved Oxygen, High Conductivity	3B
1227	Gallinipper Cr.	3.0	Aquatic Habitat	3B
407	Garrison Fk.	6.8	Aquatic Habitat	3B
1496	Gasconade R.	11.2	Fish Community	3B
7177	Glover Spring Lake	23.0	Nutrients	3B
102	Grassy Cr.	1.8	Invertebrate Community	3B
233	Greys Lake	5.2	Aquatic Habitat	3B
321	Grove Cr.	3.3	Aquatic Habitat	3B
7330	Hager Lake	9.0	Nutrients	3B
2187	Hamilton Cr.	1.8	Aquatic Habitat	3B
2165	Hayden Cr.	2.7	Heavy Metals	3B
285	Hayzlett Br.	2.4	Aquatic Habitat	3B
2181	Heads Cr.	2.7	Fish Community	3B
2182	Heads Cr.	2.4	Fish Community	3B

WBID	Waterbody Name	Size	Concern	Category
266	Hickory Cr	1.0	Aquatic Habitat	3B
308	Hickory Cr.	1.2	Aquatic Habitat	3B
335	Hickory Cr.	1.5	Aquatic Habitat	3B
229	High Cr.	6.3	Aquatic Habitat	3B
228	High Cr. Ditch	3.7	Aquatic Habitat	3B
307	Highly Cr.	3.9	Aquatic Habitat	3B
7167	Holiday Acres Lake	206.1	Nutrients	3B
350	Holland Br.	3.0	Aquatic Habitat	3B
351	Holtzclaw Creek	3.9	Aquatic Habitat	3B
338	Honey Cr.	6.7	Aquatic Habitat	3B
919	Honey Cr.	7.0	Aquatic Habitat	3B
354	Horse Fk.	4.4	Atrazine	3B
262	Howley Branch	0.8	Aquatic Habitat	3B
263	Howley Branch	2.5	Aquatic Habitat	3B
306	Huff Cr.	2.0	Aquatic Habitat	3B
234	Iowa Ditch	2.8	Aquatic Habitat	3B
1167	Jakes Cr.	11.3	Low Dissolved Oxygen	3B
286	Jenkins Cr.	7.2	Aquatic Habitat	3B
3968	Jones Branch	0.7	Sediment	3B
974	Jones Cr.	4.0	Fish And Invertebrate Community	3B
1178	Jones Cr.	3.0	Low Dissolved Oxygen	3B
5005	Joplin Creek Tributary	2.9	Heavy Metals	3B
275	Jordan Br.	7.2	Aquatic Habitat	3B
329	Jordan Cr.	1.4	Aquatic Habitat	3B
384	Keeney Cr.	4.9	Aquatic Habitat	3B
264	Kimsey Cr.	6.7	Aquatic Habitat	3B
1334	Kitten Cr.	7.2	Low Dissolved Oxygen	3B
7646	Koeneman Park Lake	5.0	Nutrients	3B
194	L. Bear Cr.	4.0	Aquatic Habitat	3B
1656	L. Berger Cr.	1.2	Invertebrate Community	3B
424	L. Blue R.	4.3	Aquatic Habitat	3B
3591	L. Fox Cr.	0.7	Fish Community	3B
1445	L. Pomme De Terre R.	6.0	Invertebrate Community	3B
403	L. Sni-A-Bar Cr.	6.7	Aquatic Habitat	3B
404	L. Sni-A-Bar Cr.	7.5	Aquatic Habitat	3B
409	L. Tabo Cr.	9.2	Aquatic Habitat	3B
250	L. Tarkio Cr.	15.4	Aquatic Habitat	3B
251	L. Tarkio Ditch	6.6	Aquatic Habitat	3B
328	L. Third Fk. Platte R.	26.0	Aquatic Habitat	3B
7064	Lake Contrary	291.0	Fish Community	3B

WBID	Waterbody Name	Size	Concern	Category
359	Lake Cr.	5.7	Aquatic Habitat	3B
7654	Lake Of The Woods Country Club Lake # 2	1.0	Fish Community	3B
7631	Lake Tebo	73.0	Nutrients	3B
7266	Lake Wanda Lee	97.0	Nutrients	3B
7044	Lakeview Park Lake	25.0	Nutrients	3B
235	Lewis Slough	2.0	Aquatic Habitat	3B
280	Lincoln Cr.	7.4	Aquatic Habitat	3B
243	Long Br.	3.0	Aquatic Habitat	3B
3531	Long Grove Br.	3.2	Low Dissolved Oxygen	3B
1617	Lost Cr.	6.4	Fish Community	3B
425	Lumpkin Cr.	0.5	Aquatic Habitat	3B
267	Mace Cr.	5.8	Aquatic Habitat	3B
7160	Marceline Reservoir	68.0	Nutrients, Turbidity	3B
3277	Mason Springs Valley	1.0	Bacteria	3B
7116	Maysville Lake	12.0	Nutrients	3B
1338	McCarty Cr.	13.2	Low pH, Aquatic Habitat	3B
2054	McDade Br.	0.7	Limited Data.	3B
231	McElroy Cr.	3.0	Aquatic Habitat	3B
324	McGuire Br.	5.4	Aquatic Habitat	3B
1321	McKill Cr.	2.7	Sulfate, Low pH	3B
1324	McKill Cr.	2.2	High Conductivity	3B
31	McLean Cr.	6.6	Nutrients	3B
3415	Middle Big Cr.	9.4	Low Dissolved Oxygen	3B
258	Middle Br. Squaw Cr.	3.0	Aquatic Habitat	3B
245	Middle Tarkio Cr.	10.0	Aquatic Habitat	3B
265	Mill Cr.	10.0	Aquatic Habitat	3B
301	Mill Cr.	10.8	Aquatic Habitat	3B
1757	Mill Cr.	4.3	Invertebrate Community	3B
4038	Mill Creek	5.5	Aquatic Habitat	3B
4039	Mill Creek Tributary	1.0	Aquatic Habitat	3B
740	Millers Cr.	1.9	Invertebrate Community	3B
755	Moniteau Cr.	14.4	Low pH, High Conductivity	3B
1315	Moores Br.	3.0	High Conductivity	3B
302	Moss Br.	2.4	Aquatic Habitat	3B
369	Moss Cr.	13.7	Aquatic Habitat	3B
343	Mozingo Cr.	5.1	Aquatic Habitat	3B
291	Muddy Cr.	5.2	Aquatic Habitat	3B
391	Muddy Fk.	8.4	Invertebrate Community	3B
49	N. Wyaconda R.	9.2	Aquatic Habitat	3B
277	Naylor Cr.	1.0	Aquatic Habitat	3B

WBID	Waterbody Name	Size	Concern	Category
392	New Hope Cr.	5.5	Aquatic Habitat	3B
309	Nichols Cr.	4.6	Aquatic Habitat	3B
344	Norvey Cr.	9.3	Aquatic Habitat	3B
260	Old Ch. L. Tarkio Cr.	5.3	Aquatic Habitat	3B
261	Old Ch. L. Tarkio Cr.	8.3	Aquatic Habitat	3B
238	Old Ch. Nishnabotna R.	13.7	Aquatic Habitat	3B
240	Old Ch. Nishnabotna R.	3.0	Aquatic Habitat	3B
284	Old Chan. Nodaway R.	10.0	Aquatic Habitat	3B
294	Old Chan. Nodaway R.	1.2	Aquatic Habitat	3B
295	Old Chan. Nodaway R.	2.0	Aquatic Habitat	3B
297	Old Chan. Nodaway R.	1.5	Aquatic Habitat	3B
298	Old Chan. Nodaway R.	1.0	Aquatic Habitat	3B
299	Old Chan. Nodaway R.	2.5	Aquatic Habitat	3B
300	Old Chan. Nodaway R.	3.7	Aquatic Habitat	3B
304	Old Chan. Nodaway R.	2.5	Aquatic Habitat	3B
305	Old Chan. Nodaway R.	2.8	Aquatic Habitat	3B
311	Old Chan. Nodaway R.	1.0	Aquatic Habitat	3B
325	Old Chan. Platte R.	3.4	Aquatic Habitat	3B
326	Old Chan. Platte R.	2.2	Aquatic Habitat	3B
332	Old Chan. Platte R.	4.0	Aquatic Habitat	3B
341	Old Chan. Platte R.	5.0	Aquatic Habitat	3B
348	Old Chan. Platte R.	1.0	Aquatic Habitat	3B
368	Old Chan. Wakenda Cr.	3.0	Aquatic Habitat	3B
4043	Old Channel Tarkio River	9.9	Aquatic Habitat	3B
26	Old Kings Lake Cr.	6.2	Nutrients	3B
2962	Otter Cr.	6.0	Low Dissolved Oxygen	3B
358	Palmer Cr.	2.8	Aquatic Habitat	3B
521	Panther Cr.	5.0	Nutrients	3B
2368	Panther Cr.	9.3	Low Dissolved Oxygen	3B
2425	Peckout Hollow	1.8	Fish and Invertebrate Community	3B
283	Pedlar Cr.	5.4	Aquatic Habitat	3B
1616	Peers Slough	3.0	Fish Community	3B
7048	Perry City Lake Upper	7.0	Atrazine	3B
349	Pigeon Cr.	7.2	Aquatic Habitat	3B
2192	Pomme Cr.	1.8	Chloride, Low Dissolved Oxygen, Aquatic Habitat	3B
313	Prairie Cr.	3.7	Aquatic Habitat	3B
2037	Red Oak Cr.	5.2	Low Dissolved Oxygen	3B
136	Reese Fk.	7.0	Low Dissolved Oxygen	3B
347	Riggin Br.	1.9	Aquatic Habitat	3B
3827	River Des Peres	3.7	Chloride, Bacteria	3B

WBID	Waterbody Name	Size	Concern	Category
2437	Roark Cr.	2.7	Invertebrate Community	3B
355	Roberts Br.	2.0	Atrazine	3B
3558	Robinson Creek	3.1	Aquatic Habitat	3B
236	Rock Cr.	2.2	Aquatic Habitat	3B
237	Rock Cr.	19.0	Low Dissolved Oxygen, Aquatic Habitat	3B
378	Rocky Fk.	4.0	Aquatic Habitat	3B
382	Rollins Cr.	7.0	Aquatic Habitat	3B
1514	Roubidoux Cr.	30.5	Invertebrate Community	3B
278	Rush Cr.	4.5	Nutrients	3B
3746	S. Dry Sac R.	4.2	Bacteria	3B
293	S. Fk. Clear Cr.	6.0	Aquatic Habitat	3B
2189	Saline Cr.	1.8	Low Dissolved Oxygen	3B
2190	Saline Creek	6.6	Low Dissolved Oxygen	3B
2345	Sals Cr.	1.5	Aquatic Habitat	3B
413	Salt Br.	5.7	Aquatic Habitat	3B
90	Salt R.	15.0	Aquatic Habitat	3B
290	Sand Cr.	4.9	Aquatic Habitat	3B
3584	Sand Cr.	1.8	Fish And Invertebrate Community	3B
952	Scott Br.	0.5	Nutrients, Low Dissolved Oxygen	3B
317	Second Cr.	11.5	Aquatic Habitat	3B
385	Shackelford Br.	5.9	Aquatic Habitat	3B
450	Shain Cr.	13.0	Nutrients	3B
87	Sharpsburg Br.	1.5	Nutrients	3B
105	Shell Br.	5.3	Nutrients	3B
396	Shoal Cr.	10.3	Aquatic Habitat	3B
1934	Shoal Cr.	7.7	Fish Community	3B
3229	Shoal Creek	0.5	Bacteria	3B
683	Silver Cr.	8.4	Low PH	3B
739	Smith Cr.	1.5	High Conductivity, Low pH	3B
353	Smith Fk.	3.0	Aquatic Habitat	3B
401	Sni-A-Bar Cr.	4.3	Aquatic Habitat	3B
5009	South Spencer Creek Tributary	4.8	Nutrients, Turbidity, Bacteria	3B
1212	Sparrow Foot Cr.	2.6	Invertebrate Community	3B
3159	Spring R.	0.5	Heavy Metals	3B
3167	Spring R.	1.0	Bacteria	3B
252	Squaw Cr.	21.0	Aquatic Habitat	3B
1486	Steins Cr.	16.6	Fish Community	3B
2355	Stewart Cr.	3.0	Fish Community	3B
156	Sugar Cr.	11.0	Invertebrate Community	3B
270	Sugar Cr.	3.0	Aquatic Habitat	3B

WBID	Waterbody Name	Size	Concern	Category
271	Sugar Cr.	6.5	Aquatic Habitat	3B
582	Sugar Cr.	12.0	Aquatic Habitat.	3B
4117	Sugar Creek	3.6	Aquatic Habitat	3B
2866	Sweetwater Br.	1.0	Heavy Metals	3B
2867	Sweetwater Br.	1.7	Heavy Metals	3B
699	Sweezer Cr.	4.9	Invertebrate Community	3B
405	Tabo Cr.	11.4	Aquatic Habitat	3B
406	Tabo Cr.	8.4	Aquatic Habitat	3B
2509	Tabor Cr.	5.6	Fish And Invertebrate Community	3B
4040	Tarkio River Tributary	2.4	Aquatic Habitat	3B
4041	Tarkio River Tributary	1.3	Aquatic Habitat	3B
4042	Tarkio River Tributary	4.7	Aquatic Habitat	3B
1281	Tebo Cr.	0.5	High Conductivity, Low Dissolved Oxygen	3B
3763	Tiff Cr.	2.1	Fish And Invertebrate Community	3B
2759	Toms Cr.	2.2	Heavy Metals	3B
239	Tr. To O. Ch. Nishnabotna R.	0.9	Aquatic Habitat	3B
241	Tr. To O. Ch. Nishnabotna R.	2.0	Aquatic Habitat	3B
365	Trib To Crabapple Cr.	1.3	Aquatic Habitat	3B
1287	Trib. M. Fk. Tebo Cr.	0.5	High Conductivity	3B
274	Trib. To Bee Cr.	1.8	Aquatic Habitat	3B
2923	Trib. To Big Cr.	1.0	Heavy Metals	3B
323	Trib. To Castile Cr.	1.2	Aquatic Habitat	3B
393	Trib. To Clear Cr.	2.2	Aquatic Habitat	3B
254	Trib. To Davis Cr.	3.0	Aquatic Habitat	3B
374	Trib. To E. Fk. Crooked R.	4.8	Aquatic Habitat	3B
429	Trib. To E. Fk. L. Blue R.	1.9	Aquatic Habitat	3B
415	Trib. To Edmondson Cr.	3.1	Aquatic Habitat	3B
232	Trib. To High Cr.	2.0	Aquatic Habitat	3B
303	Trib. To Mill Cr.	1.8	Aquatic Habitat	3B
411	Trib. To Missouri R.	5.3	Aquatic Habitat	3B
370	Trib. To Moss Cr.	0.5	Aquatic Habitat	3B
3261	Trib. To N. Indian Cr.	1.3	Invertebrate Community	3B
310	Trib. To Nichols Cr.	1.3	Aquatic Habitat	3B
281	Trib. To Nodaway R.	1.0	Aquatic Habitat	3B
314	Trib. To Prairie Cr.	1.0	Aquatic Habitat	3B
2868	Trib. To Sweetwater Br.	1.0	Heavy Metals	3B
4101	Truitt Creek Tributary	1.3	Aquatic Habitat	3B
361	Turkey Cr.	4.7	Aquatic Habitat	3B
362	Turkey Cr.	3.5	Aquatic Habitat	3B
2078	Turkey Cr.	1.4	Aquatic Habitat	3B

WBID	Waterbody Name	Size	Concern	Category
3979	Turkey Creek Tributary	1.3	Aquatic Habitat	3B
7155	Unionville (Old) Lake	13.0	Atrazine	3B
412	Van Meter Ditch	4.5	Aquatic Habitat	3B
2472	W. Fk. Big Cr.	3.0	Invertebrate Community, Low Dissolved Oxygen	3B
379	W. Fk. Crooked R.	6.6	Aquatic Habitat	3B
380	W. Fk. Crooked R.	9.8	Aquatic Habitat	3B
929	W. Fk. Post Oak Cr.	12.8	Aquatic Habitat	3B
366	W. Fk. Wakenda Cr.	3.3	Aquatic Habitat	3B
367	W. Fk. Wakenda Cr.	7.8	Aquatic Habitat	3B
230	W. High Cr.	2.8	Aquatic Habitat	3B
244	W. Tarkio Cr.	1.2	Aquatic Habitat	3B
246	W. Tarkio Cr.	9.6	Aquatic Habitat	3B
360	Wakenda Cr.	29.2	Aquatic Habitat	3B
364	Wakenda Cr.	10.6	Aquatic Habitat	3B
2136	Wallen Cr.	1.4	Invertebrate Community	3B
2374	Ward Br.	3.3	Bacteria	3B
346	White Cloud Cr.	12.8	Aquatic Habitat	3B
259	Wildcat Cr.	4.0	Aquatic Habitat	3B
387	Williams Cr.	9.1	Aquatic Habitat	3B
381	Willow Cr.	6.5	Aquatic Habitat	3B
3136	Wolf Hole Lateral	9.5	Aquatic Habitat	3B

APPENDIX K - RESPONSIVENESS SUMMARY
Summary of Proposed 2022 303(d) Comments

2022 303(d) List
Responses to Public Comments
Received During the Public Notice Period

Public Notice Period
October 13, 2022 – January 18, 2023

Missouri Department of Natural Resources
Water Protection Program
PO Box 176
Jefferson City, MO 65102-0176
800-361-4827 / 573-751-1300

Introduction

Pursuant to 40 C.F.R. § 130.7, States, Territories, and authorized Tribes must submit biennially to the U.S. Environmental Protection Agency (EPA) a list of water-quality limited (impaired) segments, pollutants causing impairment, and the priority ranking of waters targeted for total maximum daily load (TMDL) development. The Missouri Department of Natural Resources (Department) placed the draft 2022 303(d) List of Impaired Waters on public notice from October 13, 2022, to January 18, 2023. All original comments received during this public notice period are available online on the Department's website at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters. Comments were received from the following groups or individuals:

1. Rhonda Ferrett
2. Robert Brundage, Brundage Environmental and Ag Law, LLC
3. City of Kansas City
4. City of Springfield
5. U.S. Environmental Protection Agency Region 7
6. Josh Stevens
7. Gary Stilts
8. Lawrence Haflich, representing ICOM – verbal comments provided at the hearing
9. Charles Miller – verbal comments provided at the hearing
10. Missouri Farm Bureau

This document summarizes and paraphrases the comments received, provides the Department's responses to those comments, and notes any changes made to the final proposed 2020 303(d) List of Impaired Waters or supporting documentation.

Summary of Department actions as a result of public comments:

Waters Proposed to be Delisted from the 2022 303(d) List

1. E. Fork Locust Creek WBID – Chloride (Water)
2. Meramec River WBID 2183 – Lead (Sediment)
3. Lost Creek WBID 3278 – *E. coli* (Water)
    i. A TMDL was approved by EPA during the public notice period.
4. Little Lost Creek WBID 3279 – *E. coli* (Water)
    i. A TMDL was approved by EPA during the public notice period.
5. Willow Branch WBID 3280 – *E. coli* (Water)
    i. A TMDL was approved by EPA during the public notice period.
6. Bens Branch WBID 3980 – Cadmium (Sediment and Water), Lead (Sediment), Zinc (Sediment and Water)
    i. A TMDL was approved by EPA.

Summary of Comments and Department Responses

1. **Rhonda Ferrett**

Rhonda Ferrett provided comments with concerns of a beef processing facility proposed to be built in 2023, which would be in the watershed of and discharge to Peruque Creek.

I am very concerned on the effects of the beef processing plant that will be built in 2023 and its effects on the Peruque Creek. I have read that Industrial livestock and poultry slaughtering and processing plants dump huge volumes of pollution into America's rivers, threatening our health and harming our environment. Despite Clean Water Act requirements, the EPA has not updated decades-old pollution standards to protect the public. Although I am told that all wastes will be captured onsite and underroof, I cannot believe that 2,400 cattle arriving daily at this plant will not have an impact on the watershed. I ask you to please investigate the impacts of this huge project while there is time to gather data before the plant is built and after it is fully operational. Additionally, this data should be made public so we can rest assured our watershed is not impacted.

Department Response

The Department appreciates the comment. All new facilities must go through antidegradation review and are given permit limits protective of water quality standards. As part of the antidegradation review for this facility, Department staff conducted water quality modeling using appropriate conservative margins of safety to establish pollutant effluent limits that will be protective of water quality in Peruque Creek as well as the water quality downstream in Lake St. Louis. As part of a processing facility's permit, stormwater concerns are also reviewed. Any waste exposed to precipitation that has the potential to enter waters of the state must be controlled to prevent runoff. Missouri Clean Water Law and effluent limit regulations at 10 CSR 20-7.015 require discharging facilities to meet and follow all established permit limits and permit conditions. Failure to do so is a violation and is subject to Department enforcement action. The Department will public notice the operating permit for the facility of concern as well as the antidegradation review. Public notices for operating permits can be found on the Department's website (https://dnr.mo.gov/water/what-were-doing/public-notices.) Water quality data can be found on the Department's website (https://apps5.mo.gov/mocwis_public/wqa/waterbodySearch.do) and can be requested through an Open Records Request (https://dnr.mo.gov/open-records-sunshine-law-requests) or by emailing ImpairedWaters@dnr.mo.gov.

2. **Robert Brundage, Brundage Environmental and Ag Law, LLC**

Robert Brundage provided comments in regard to two streams:

1. East Fork Locust Creek WBID 610 – Chloride (Water)
2. Meramec River WBID 2183 – Lead (Sediment)

For both of these streams, Robert Brundage asked if the Department had collected data recently on these streams and if so, asked that the Department re-assess the water bodies including the more recent data.

Department Response

The Department appreciates the comments provided by Robert Brundage.

Comment 1:
The Department sampled East Fork Locust Creek (WBID 610) in 2021 and 2022. This data is past the cutoff date used for drafting the 2022 303(d) list, but the Department is willing to incorporate newer data on a case-by-case basis if the new data will result in listing or delisting a water, and the data is brought to our attention during the public notice period. The additional samples collected in 2021 and 2022 indicate East Fork Locust Creek is now meeting the water quality standard for chloride and should no longer be listed as impaired for chloride. The Department will propose to delist this water body. The Department has included the new data in an updated assessment worksheet attached to the 303(d) list.

Comment 2:
The Department collected sediment samples from the Meramec River (WBID 2183) in 2022. This data is past the cutoff date used for drafting the 2022 303(d) list, but the Department is willing to incorporate newer data on a case-by-case basis if the new data will result in listing or delisting a water, and the data is brought to our attention during the public notice period. The additional samples collected in 2022, combined with past data, indicate the geometric mean lead concentration in sediment are below the Listing Methodology Document thresholds and the Meramec River should no longer be listed as impaired for lead in sediment. The Department will propose to delist this water body and will continue to sample the Meramec River bed sediment. The Department has included the new data in an updated assessment worksheet attached to the 303(d) list.

3. City of Kansas City

The City of Kansas City provided comments asking the Department to lower the TMDL priority for the Blue River (WBID 417, 418, & 419), Brush Creek (WBID 3986), Indian Creek (WBID 420), Mill Creek (WBID 4066), Missouri River (WBID 226 & 356), and Line Creek (WBID 3575). These streams are listed as impaired for *E. coli*, low dissolved oxygen, and/or chloride. The City asked that the Department lower the TMDL priority due to an ongoing consent decree and the implementation of the Cities KC Smart Sewer program to reduce combined sewer overflows and sanitary sewer overflows. The City asked that the Department delay establishing a TMDL until after the City has fully implemented the Smart Sewer improvements and met the consent decree performance criteria by 2040.

Department Response

The Department appreciates the comment made by the City. To maintain consistency with federal requirements and metrics, we are only identifying specific schedules for waters planned for TMDL development in the two year period between listing cycles. The current list does not identify any streams in the Blue River watershed as high priority for TMDL development. Although specific schedules aren't identified for the medium priority waters, we are aware of other plans to address nonpoint source loading in the Blue River watershed currently underway though our Section 319 Nonpoint Source Unit. Because those nonpoint source reduction efforts are not yet final, and we would want to allow some time to show water quality improvements, the Department is not expecting TMDL development to occur for a number of years and potentially multiple 303(d) listing cycles.

4. City of Springfield

The City of Springfield provided comments discussing their continued work through the City's Integrated Plan to address *Escherichia coli* (*E. coli*) in Galloway Creek. The City is in agreement with the Department's low prioritization of a TMDL. This will allow the City to continue implantation of their Integrated Plan. The City is planning to sample Galloway Creek in 2023 through 2025 for *E. coli* and plans to share the data with the Department for re-assessment of Galloway Creek in the 2024 or 2026 cycles.

Department Response

The Department appreciates the City's commitments and efforts to address *E. coli* in Galloway Creek and looks forward to receiving the City's data.

5. U.S. Environmental Protection Agency, Region 7

The U.S. Environmental Protection Agency, Region 7 provided comments that the Department's Listing Methodology Document may not be sufficient for assessing chronic chloride conditions for Coldwater Creek and Watkins Creek during winter storms and runoff associated with those events.

Department Response

The Department continues to assert the validity of the method for assessment of chronic chloride criteria, but invites U.S. EPA to participate in the state's public participation process for the 2024 Listing Methodology Document and provide examples of how the state might better assess chloride data surrounding winter storm events.

6. **Josh Stevens**

Josh Stevens provided comments expressing disappointment in the length of the list of impaired waters. Josh Stevens expressed concerns regarding the state's ability, or inability, to sample all of the waters in the state as well as the status of all of the other water bodies in the state. Josh Stevens additionally expressed thanks for maintaining and public noticing the list.

Department Response

The Department appreciates the comments. The Department drafts a monitoring strategy for the state of Missouri, which can be found on the Department's Impaired Waters website. This strategy outlines current water quality monitoring efforts, as well as gaps for monitoring water quality throughout the state and the costs needed for filling those gaps. The Department also writes Missouri's Water Quality Report, also known as the 305(b) or Integrated Report. This report can be found on the Department's Impaired Waters website. This report summarizes that status of all of the waters in the state including both impaired and unimpaired waters. The Department encourages Josh Stevens to become involved with Missouri Stream Team Program and the Volunteer Water Quality Monitoring Program. The Stream Team Program provides citizens with ways to become more engaged with their local environments as well as training opportunities for monitoring your local streams.

7. **Gary Stilts**

Gary Stilts provided comments in appreciation of the Department's monitoring efforts. Gary Stilts suggests the Department start doing DNA sampling for *E. coli* impairments. Gary Stilts additionally suggested the Department post water quality findings specific to public health and safety at each public access location for lakes or rivers.

Department Response

The Department appreciates the comments. The Department will continue to look into the methodology, availability, accuracy, and cost of DNA source tracking for *E. coli*. The Department currently posts public health and safety relevant water testing results for *E. coli* at all public beach areas for which the Department is directly responsible (i.e. State Parks). The Department is happy to provide water quality sampling information and work with federal, state, and local public health agencies, or other owners of public access points, to post information at the owner's discretion.

8. **Lawrence Haflich, representing ICOM**

Lawrence Haflich provided comments at the January 11, 2023 public hearing. Lawrence Haflich's comments are specific to Lost Creek, Little Lost Creek, and Willow Branch, all in Newton County, near Seneca Missouri. Lawrence Halfich provided comments regarding the proposed TMDL for Lost Creek, Little Lost Creek, and Willow Branch. [The TMDL addresses

E. coli] Lawrence Haflich expressed concerns with the undersized, failing, or leaking septic systems in the watersheds of the streams as well as concerns that agriculture may not be the total source of the problem.

Department Response

The Department appreciates Lawrence Haflich's comments and concerns. The TMDL for these water bodies assigns waste load allocations to point sources and load allocations to nonpoint sources. Septic systems are designed to not discharge and therefore are given a load allocation of zero, i.e they are not allowed to contribute any bacterial load to these watersheds. If the septic systems are not being operated and maintained as designed, the Newton County Health Department is responsible for administering and enforcing the permits for onsite septic systems. Newton County has an ordinance for enforcing the compliance with the onsite septic permits. The Department encourages Lawrence Haflich to work with the Newton County Health Department to report failing, leaking, or discharging septic systems of concern, as well as the County Commissioners for enforcement of county ordinances.

9. Charles Miller

Charles Miller provided comments at the January 11, 2023, public hearing. Charles Miller's comments were specific to the Salt River impairment for low dissolved oxygen. Specifically, Charles Miller was concerned with the delisting of the River and the source of the impairment being the Clarence Cannon Dam owned and operated by the Army Corps of Engineers (Corps). Charles Miller encouraged the Department to reach out to the Corps to see if anything can be done cooperatively to get the water back in compliance with water quality standards.

Department Response

The Department appreciates Charles Miller's comments. The 303(d) List is a list of category 5 impaired waters. These are waterbodies impaired by a discrete pollutant and which require a pollution control plan to correct the impairment. Pollution control plans typically include National Pollutant Discharge Elimination System (NPDES) permits, TMDLs, or other plans with regulatory requirements. The Department is delisting the Salt River to category 4C, which is a category of impaired waters that are not caused by a discrete pollutant, and thus a pollution control plan is not needed or is not possible. The Army Corps of Engineers is aware of the low dissolved oxygen issues below Clarence Cannon Dam, caused by the operation of hydroelectric turbines for power generation. The Corps created and maintains the Mark Twain Lake Dissolved Oxygen Working Group which includes staff from the Department of Natural Resources, Missouri Department of Conservation, and the Southwestern Power Administration. Annually, the Corps coordinates on updating their Operational Action Plan which states the purpose is "*To provide the framework and criteria for interagency cooperation and actions which may help protect aquatic life downstream from Clarence Cannon Dam from low dissolved oxygen (D.O.) impacts to the extent reasonably possible while preserving the flood control and hydropower benefits of the project to the maximum extent possible. The cooperation and actions will be accomplished through modifications to routine operations at the dam. A D.O. working group has been formed by the agencies involved to address this action plan and to develop investigations and implementation as funding allows of a long-term solution(s) to low D.O. concentrations.*"

The Department is not claiming the Salt River is no longer impaired, but that the 303(d) list is not the appropriate place to list the water under the Clean Water Act. The Department maintains a list of category 4 water bodies in Missouri's Water Quality Report, also known as the 305(b) or Integrated Report. The report can be found on the Department's Impaired Waters website. This report summarizes that status of all of the waters in the state including category 4C waters. Appendix E of the report contains a list of all of the waters believed to be impaired, but are not listed on the 303(d) list because either an EPA approved pollution control plan exists to address the impairment, or the water is impaired by a non-discrete pollutant.

The Department will continue to work with the Corps and the other stakeholders in the workgroup on ways the Corps might be able to improve operations of the dam and potentially mitigate the low dissolved oxygen effects downstream in the Salt River.

10. Missouri Farm Bureau

The Missouri Farm bureau provided comments on the following areas:

- Missouri Farm Bureau is opposed to proposals to expand classified streams in Missouri that should not be classified and urged the Department to use its authority to keep waters that should not be classified from being classified.
- Missouri Farm Bureau urged the Department to establish a process for declassification of waters.
- Missouri Farm Bureau urged the Department to designate only those uses for classified waters that are in fact supported by those waters.
- Missouri Farm Bureau questions the necessity of listing the entire waterbody as impaired for the Grand River and Middle Fork Grand River and outreach to landowners before the list becomes publicly available.
- Missouri Farm Bureau requests to be notified of future draft TMDLs.

Department Response

The Department appreciates the comments. Stream classification is dependent upon the water quality standards review process for determining if a water body is a water of the state and if that water of the state should have designated use or general use protections. More information can be found on the Department's Water Quality Standards Technical Assistance website under the "Presumed Use Review" section or by contacting WQS@dnr.mo.gov.

The Department is working on the technological and electronic details for creating smaller assessment units to better define the listed length of impaired waters. The Department encourages Missouri Farm Bureau to provide additional information or data that indicates portions of the Grand River or Middle Fork Grand River are not impaired. Additionally, the Department would be happy to work with Missouri Farm Bureau to develop a Quality Assurance Project Plan for collecting samples which the Department could incorporate into future assessments.

The Department conducts a 90 plus day public involvement process regarding listing water bodies as impaired. Department staff are happy to meet at any time during this process to answer questions, provide information, or generally discuss impaired water concerns of stakeholders.

The Department encourages the public as well as Missouri Farm bureau to access the Department's Impaired Waters website and click on the green envelope to sign up to be on the GovDelivery email notification group for when the 303(d) list is placed on public notice.

For notification of future TMDLs that are placed on public notice, the Department has added Sydney Winn's email address to the TMDL GovDelivery email notification group notification list.